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US-PAT-NO: 3390548
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TITLE: DRIVING ARRANGEMENT FOR KNITTING MACHINES OR THE LIKE

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OCR Scanned Text - LPAR (5): ited 3,390,548 DRIVING ARRANGEMENT FOR KNITTING MACHINES OR THE LIKE Thomas W. Rogerson and Gerald A. Sweeney, Harwinton, Conn., assignors to General Time Corporation, New York, N.Y., a corporation of Delaware Filed Nov. 20, 1962, Ser. No. 238,968 13 Claims. (Cf. 66-56) The present invention relates to an electric drive and more particularly to an automatic electrical driving arrangement for a knitting machine or the like. It has been common practice in the knitting industry to employ variable speed motors havin.- relatively complex control arrangements in order to vary the speed setting to accommodate the machine to different kinds and weights of yarns and to different modes of operation as required during the knitting of the different parts of a stocking. Accurate speed control is necessary to insure maximum output of the niachine while, nevertheless, preventing damage to the needles, sinkers and other related parts of the machine. It is particularly desirable that the machine be halted just as promptly as possible following breakage of the yarn or breaka.-e of a thread or other fragile knitting element in order to prevent snowballing of the damage to other parts of the machine and to minimize "down" time. Prior driving end control arrangements for knitting machines have have not been '@faif safe" upon cessation of control current, since they have suffered from the effect of inertia and, where plug-ing or similar techniques have been used to control inertia, they have required the rnaking and breaking of lar-e amounts of electric current. Moreover, it bas been difficult to adjust the machine for autom,,itic speed change between successive modes of operation or steps in the production of the knitted article. It is an object of the present invention to provide a knitting machine drive which is capable of extremely rapid response to a control signal, and which is substantially free of the inertia which characterizes drives of @conventional type. Thus, it is an object to provide a knitting machine drive which may be turned off upon breakage of the yam, a needle or associated knitting element so rapidly as to prevent breakage of other needles in the series. It is a more detailed object to provide a knitting machine drive in which immediate reduction in speed may be secured without necessity for employing "plug.-ing" usually required to overcome inertia and which may be readily "inched" or "jogged" during setup or adjustment of the machine without necessity for switching or controllin,a lar,-e curreiits. It is another object of the present invention to provide a novel arrangement for automatically switching the drive to provide predetermined and automatically maintained speeds in the successive modes of operation, with each of the speeds being easily settable on separate potentiometers mounted oii the control panel. It is a related object to provide a novel arrangement for switching the potentiometers without necessity for inter- posed relay' It is another object of the present invention to p,rovide a driving arrangement for a knitting macbine or the like which is particularly useful where a lar-e number of w@achines are operated at the same location. In this connection it is an object to provide a driving arrangement for the knitting machine which permits all of the machines to be driven from the same power source usually by means of a line shaft but which, nevertheless, permits the speed at the input of each of the ma- chines to be independently adjustable and automatically maintained in spite of wide variations in

the speed Una States Patent Office 3,390,,548 Patented July 2, 1968 2 of the power source It is a related object to provide a driving arrangement for a plurality of knitting machines in the same room but in which the total amount of dissipated heat is substantially less than that where individually controlled drivin.- motors are used on the- machines. It is still another object to provide a drive for knitting machines or the like which enables the driving speed to be maintained with a hi.-h degree of accuracy lo but which, nevertheless, is independent of the type of driving motor wh@@ch may be used, thereby enabling motors to be employed which are common to the particiilar area, regardless of voltage, whether A.-C. or D.-C., and regardless of whether the motor has good or poor speed regulation. Thus it is an object to provide a knitting machine having a built-in coupling mechanism and -coiitrol circuit but which may be universally used in any part of the world. It is yet another object related to the foregoing to provide a drive for a knittin- machine or the like which is extremely simple, consis'tin.@ of only two rotating parts under the control of a simple control circuit readily serviced and maintained by local technicians having only a limited amount of knowled-e and ability in elec- tronic control techniques. Moreov'er, the entire control circuit or subassemblies thereof may be fabricated in the form of compact plug-in units so that a new unit may be substituted promptly for a defective one and with the actual servicing being taken care of at a cen- tral service center. It is a related object to provide a driving and control arran.-ement for a knitting machine or the like wbich is not only simple but which is capable of operating without maintenance for long periods of time, avoiding the common sources of trouble including commutators, slip rings, relay or contactors, all of which are si@.bject to the effects of dirt and wear within a relatively short period of time. It is still another object of the present invention to provide a variable speed electric drive having speed re.oulation which is as good and in many cases superior to that of conventional motor drives and wbich is, in addition, lower in initial cost, particularly in the integral horse power range. It is an object of the invention, in one of its aspects, to provide a novel and effective oil clutch in which a film of oil is maintained between input and output discs together with means for chan.-ing the thickness of the film correctively to maintain a predetermined but ad- rj(justable output speed. It is another object of the invention, in one of its aspects, to provide a drive which utilizes intentional slippage but in which the energy lost in the slippage is constantly and efficiently dissipated so that the device may be operated for long periods of time, where necessary, at high slippage rates, without noticeable wear and without build- up of excessive temperatures. It is finally an object to provide a clutch control circuit employing transistors which avoids the effects of high reverse voltage and current leakage, particularly where the device is employed in spaces having a high ambient temperature. As oiie of the features of the conti-ol the power output element may be "locked in" to the I power input element so that there is no loss of power through the drive. Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawings in which: FIGURE 1 shows a portion of a knitting machine including a driving arrangement - constructed according to the teachings of the present invention.

OCR Scanned Text - LPAR (7): 3)390;548 5 about immediate disabling of the drive mechanism and stoppage of the machine so that dztmage to the -niachine is minimized. At the lower right of FIG. 1 is disclosed a stocking ejector apparatus. As is well known to those skilled in the knitting art, the purpose of such apparatus is for pneu-matically ejectidg a finished product.

Up to the present time, and to the best of our knowledge, machines of the type disclosed herein utilized a separate motor 'Lor product ejecting purposes other than the motor used for the variable speed drive. Furthermore, it is also well known that it is desirable to have the blower operating motor developing a constant speed in order to maintain a constant eject force within the blower. Thus it can be- appreciated that the variable speed drive motor was unsuitable for such application as any alteration of its speed altered the eject conditions within the blower. By the example arrangement of the variable speed drive of the instant invention (FIG. 1) only a single constant speed drive @motor is required where@by a variable speed and eject function is efficiently obtained. Moreover, the drive motor benefits from the cooling effect given off by the blower unit due to its convenient location adjacent thereto. Thus the single drive motor serves a dual function which results in a reduction of overall expense and a,Tords sought after compactness. Turning attention next to t' ie construction of the coupling 25 which is set forth in longitudinal section in FIG. 3, it will be noted that it includes a housing 100 having a,, cup shaped portion 101 and an end bell 102, the two sections being clamped to.aether by machine screws 103 enga-ing mated flanges 104, 105, respectively. Extendin.from the left hand end of the machine is the input shaft 24 and extending from the right band end of the machine, and alined therewith, is the output shaft 26. The input shaft is journaled iii spaced bearings 111, 112 so as to be capable of supporting an overhanging load. In the preseiit instance the bearings are mounted in a sleeve 113 and are spaced apart by a spacer 114,wbich engages the inner races. For the purpose of preventing escape of lubricant alon-, the shaft, an oil seal 115 is provided which n-iay be of any suitable type, commercially avail@tble. Similarly, the output shaft 26 is supported on bearin-,s 121, 122 mounted in a sleeve 123 and separated by a spacer 124, sealing being taken care of by a seal 125. The housing is intended to be operated approximately half full of oil or other viscous fltiid capable of efficient lubrication and cooling. An 0-ring 126 is preferably interposed between the portions 101, 102 of the housing to provide an effective seal. In carrying out the present invention, a driving disc or rotor is secured to the input shaft and a driven disc, or armature, is secured to the output shaft, with means for setting up a variable -magnetic flux between tlie@m, tbereby to regulate the olitput torque and speed. Turning attention first to the rotor, which bas been indicated at 130, it includes a hub 131 mounting a disc portion 132, the hub being secured to the shaft by a key 133 and locked against endwise,movement by any suitable means, preferably snap rings such as the ring 134 seated in a shallow groove formed on the shaft. The disc 132 is of composite construction including coaxial sleeves 135, 136 of magnetic rnaterial spaced apart by a nonmavnetic annulus 137 to form separate annular poles 141, 142. Surrounding the sleeve 136 is a further annulus 143 to which is cemented, or otherwise secured, an annular friction member 145. Cooperating with the rotor 130 is an armature 150 n-tounted on a hub 151 pro-viding a freely slidable splined c,onnection 152. The armature is preferably made of soft steel or other permeable magnetic material, completing the magnetic circuit between the poles 141, 142 on the rotor previously referred to. For the purpose of establishing a flow of flux through the poles, a stationary annular electromagnet 160 is provided baving poles 161, 162 thereon which axially over- 6 lap, and have a close spacing with respect to the pole monl@bers 135, 136 on the rotor. The ma-net 160 is of "U" cross section accommodating an annular coil 165 to which current is conducted by leads 166, 167 leading to a connector 168 outside of the machine. It will be apparent from FIG. 4 that the flux, indicated at F, passes from the electromagnet through the annular poles 135, 136 for magnetic attraction of the armature which is free to move on its central spline

connection 152, the amount of force being dependent upon the current flow through the windin,-. Preferably the friction n-aterial 145 is made flush with the outer pole 142 while the inner pole is undercut to provide a small amount of clearance 146 on the order of a few thousandths of an inch. In accordance with one of the aspects of the present- invention, sharp edged, radial grooves are formed in the face of the armature for the purpose of conductin-. the oil to the faces which are in engagement and to provide an escape path for the oil film as the magnetic attraction is increased with resulting increase in rotational drag. Thus, referring to FIGS. 5 and 6, radial grooves 171-176 are cut in the face of the armature spaced at equal angles. Each of the grooves defines edges 177, 178 -which are preferably relatively sharp and each of the grooves is of square cross section, having an area which may be on the order of .01 square inches. It should be here pointed out, however, that si-milar grooves 171-176 may be formed in the friction member 145 (instead of armuature 150) and through the outer edge of annular pole 142 to provide for the above explained oil circulation without departing from the spirit of the invention. For the purpose of admitting the oil to the inner ends of the grooves 171-176, the ma-net 160 is so dimensioned with respect to the hub 131 as to provide an annu- lar oil passageway 181, and openings 182 are formed in the rotor at spaced intervals (see FIGS. 3, 7 and 8). As the input shaft turns, and assuming flow -of current tlirough the electromagnet, drag torque is applied to the armature so that it too begins to turn. As will be set forth in greater detail in connection with the control circuit, the current through the coil under starting conditions is hi,-h and the attractive force on the armature is correspondingly great so that the film tends to be squeezed out from between the engaging surfaces resulting in a high value of transmitted torque and with imniediate acceleration of the output shaft to a speed approaching the desired value. Simultaneously, the centrifugal force, acting upon the oil in the armature grooves, causes oil to be discharged radially outward along the path P shown in FIGS. 5 and 8. Because the grooves are in multiple, having substantial total area, a large volume of fluid is conducted. For example, in the case of a practical coupling having a rating of V2 hp, the rate of flow may be on the order of approximately 50 cubic inches per @minute when rotating at 1800 r.p.m. It is to be noted that, while the oil conducting grooves are formed in the output disc rather than the input disc, the output disc is immediately effective on startup and has the advantage of rotating thereafter at a maintained speed. The clearance at the pole face 141 augments the grooves in providing replenishment of the fluid to the space 138 (FIG. 8). Conversely, when prompt shutoff is required the current in the coil 165 is immediately dropped to zero by the control circuit to be described, thereby releasing the mag- ntic attractive force upon the armature. To insure prompt separation, the armature preferably carries a set of tbree Q-@-parator springs 183 having separator buttons 184 wbich engage the rotor face (see FIG. 5). One of the spring asse@mblies is shown in FIG. 4, wherein a rivet passes through a bole at the lower portion of spring 183 and is pressed into a bole provided in the armature 150. The button 184 loosely fits in a second hole provided at the upper portion of armature 150. Button 184 is fixed to the upper portion of sprin.- 183. With the coil 165 in ener- gized condition, button 184 is drawn toward the friction

OCR Scanned Text - LPAR (9): 9 plied to the clutch coil, an amplifier 240 is provided having direct coupled transistors 241, 242. The emitter of the first transistor has a resistor 243 and is directly connected to the base of the second. Both eniitters are supplied from the positive terminal 202 of the po-,Aer supply and the collectors are jtiiiipered together and returned to the negative

terminal 203 of the power stipply w-ith the clutch coil 165 in series therewith. A diode 244, polarized as shown, is connected across the base-emitter, or input, circuit of the first transistor to protect the latter against reverse ovei-voltage. To insure that the output current may be reduced to zero upon shutoff, particularly under hi-,h ambient temperature conditions, means are provided for applyin.- a small amount of positive bias to the base of the second tra,.qsistor. This is accompiished by employing a constant voltage drop diode 245 or "stabistor" in the emitter circuit of the transistor 242 with the circuit being completed throiigh a series resistor 246. Upon flow (>f cutrent from the power supply through diode 245 and resistor 246 a constant voltage drop occurs through the diode, making the base slightly positive with respect to the emitter. IF-inally, to prevent the transistors from beina injured by the inductive kick from the clutch coil 165 when the latter is deener.-ized, the coil is short-circuited by a diode 248. While the operation of the circuit described above will be apparent to one skilled in the art, it may be described briefly as follows. It will be assumed that tlle clutch input shaft is being turned at a certain nominal speed by the motor, that a load is connected to the output shaft, that the first potentiometer 215 is in the active position, and that sufficient current is flowing through the clutch coil so that a predetermined output speed is obtained. In the event that the output load drops slightly resulting in a tendency for the output speed to increase, the riet input current applied to the base of the first transistor decreases slightly, thereby decreasing its current output which is fed to the emitter and base of the transistor 242 whereupon the output of transistor 242 is decreased. Then the load current of the two transistors which flows through the clutch coil 165 tends to decrease slightly, reducing the drag torque so that there is a corrective, slight increase in speed of the output shaft and restorin.- a condition of eqtiilibrium. A corrective change in the same direction takes place upon any tendency for the speed of the input shaft to increase, for example, as a result of a sudden increase in line voltage. The converse takes place when there is a decrease in the output speed from the desired equilibrium value due to added loading or a drop in the line voltage supplying the motor. Under such conditions the resulting unbalance between the tachometer circuit and reference circuit causes a slight increase in the current flowing tlirough the base circuit of the transistor 241, increasing the emitter current and thereby slightly increasing its current output which is fed into the emitter and base of the transistor 242 whereupon the output of transistor 242 is increased. Then the load current of the two transistors which flows through the clutch coil 165 tends to increase slightly, increasing the drag torque so that there is a corrective, slight decrease in the speed of the output shaft that restores a condition of equilibrium. It is one of the characteristics of conventional transistors, particularly where of the germaniii-m type, and particularly under high temperature conditions, that the transistor output circuit is conductive even wher e the input current is zero. The presence of the stabistor 245 in the circuit insures that under zero input condit'ons there will be sufficient positive bias on the base with respect to the emitter so that the current through the clutch coil will be substantiallly zero. By using the above described combination of clutch and control circuit, the speed regulation may be held 31390)548 to within approximately 2% or better in spite of variations in input sp.-ed over a wide range. In accordance with one of the aspects of the present invention, a novel contact arrangement is employed including both normally open and normally closed contacts in the switches 78, 79 to permit switching between the potentiometers 215, 217 directly witbout use of an interposed relay. Thus, we provide in switch 78 normally closed contacts 78a and normally opeii contacts 78b, and we also provide, in switch 79, normally open contacts 79a and normally closed contacts 79b. Contacts

78a, 79a are arranged in parallel with one another and connected in series with the output terminal 216 of potentiometer 215. The remaining contacts 78b, 79b are connected in series with one another and in series with output terminal 218 of potentiometer 217. As a result, potentiometer 217 is connected in the circuit only wben switch 73 is actuated and when switch 79 is in its norinal, or non-actuated position. Under such conditions it will be apparent that contacts 78h are closed so that a circuit is co@-npleted to potentiometer 217 through the normally closed contacts 79b, whereas the contacts associated with the potentiometer 215 are bo'ch open circuited. Referring briefly to the other possible conditions, it will be appareilt that when neither switch is actuated, potentiometer 215 is in the circuit via normally closed contacts 78a, When only switch 79 is aettiated, potentionmeter 215 is again in the circuit since the closure of contacts 79a and opening of contacts 79b is simply re- dundant. Finally, it will be apparent that when both switches 78 and 79 are actuated the circuit to potentiometer 215 is set up through closure of coiitacts 79a, with the circuit to the potentiometer 217 bein.- opened by opening of contacts 79b. In short, the contacts in the two switches are connected to perform a logic function, with the potentiometer 217 bein.- connected iii the circuit only during one of the four possible switch conditions. The ability of the device to maintain the speed constant at an adjusted value is particularly important in a knitting machine m,here operation at maximi:im efficiency re- quires a certain operating speed for certain operating parameters, notably the type and gauge of the yarn being used. The drive is well suited for use in those areas where wide swings in line voltage are encountered or where wide chan,-es in input speed may occur, as where water power is being utilized as the power source. To take a practical case it may be assumed thel the desired output speed is 1800 r.p.m. and that the available speed at the input shaft is a nominal 2200 r.p.m., with substantial variation possible below this value. Usin-, the present control arrangement the speed of the input shaft would have to drop more than 18% to below 1900 r.p.m., before there would be any reduction in output speed below the set value. Consequently, knitting machines employ- ing the present invention may be sent to any country of the world independently of the kind of power available with assured efficiency of the operation of the machine, provided only that the input speed does not fall below a stated minimum. The clutch a-@id control circuit, comprising a system, have a short "time constant," i.e., are capable of responding immediately to changes in the operating conditions. Thus, upon breaking the yarn in the knittina machine, causing momentary short eircuiting of the relay coil, the resultin- dropout removes power from the clutch with practically no overtravel due to inertial eff-ects and without necessity for resortin.- to "plug.-ing." The circuit may be readily inched or jog-ed by holding the start button down and releasing the @stop buttoi in short pulses. Control over the entire speed raiige is achieved using low values of control current so that conventional and inexpensive circuit components may be used permitting compact unit, or "plug in," construction. Because of the small amount of current drawn by the control system, the voltage across the power siipply output terminals 202,

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OCR Scanned Text - LPAR (10): 3 Besides the "Operations Research" approach and the designed experiment discussed above the control or operation of a plant is largely a matter of experience and judgment of the operator. While many instruments or devices a@-e provided to aid the operator, these instruments or devices serve primarily to indicate the operating conditions or to make adjustments which take into consideration only current conditions and many adjllstments looking toward future operations of the plant are made entirely on the judgment and experiepce of the operator. In addition the results of the operator's judgment must wait for a lapse of time and not until that lapse is it known whether the operator's judgment was correct or erroneous. T'his invention minimizes the above deficiencies through a new approach to the optimization of complex processes of manufacture. Briefly the invention contemplates substantially instantaneous evaluation of actual dollar value of both input of raw materials and output of finished product. AlsO the value of internally stored "in process" product is appropriately included. In addition process variables which fall under the headin- of variable costs and other factors which fall under the heading of fixed costs are continuously evaluated. In so doing it has been found that a profit rate" may be obtained according to the followin,@ equation: Profit rate@(QXQ')-(FC)-(VC) In the eqiiation "profit rate" is expressed in dollars per unit time. Q is the produced quantity of products per unit time. Q' is the unit price of the product. (FC) represents the fixed cost per unit time. Under this heading will be found such items as: (a) depreciation; (b) overhead cost; (e) fixed labor; (d) building heat; (e) etc. (VC) represents the variable cost per unit time. Under this heading will be found such items as: (a) raw materials; (b) additives; (c) steam; (d) other power requirements; (e) variable labor; (f) etc. While the profit rate is constantly computed slight variations in process variables are introduced by means of a carefully prescribed pattern. This pattem requires that small chan-es are made in two or three variables from their standard op-@ratin.- conditions. Continued manufacture of material under the conditions described by the pattern will allow information to acclimulate while material is being produced. While the process variables are being manipulated, both profit rate and product restraints are continuously surveyed. A particular set of variables will be manipulated only as long as: (1) The profit rate increases, and (2) The product restraints are not violated. From the above it becomes abundantly clear th.at this procedure will result in an optimum economic operating condition without interrupting the particular process of manufacture, without having to mathematically describe the interrelationship between the process variables and without having to rely on a laboratory model of the apparatus used for this particular process. Elimination of these three points are the rnain objects of this invention. An important feature of the invention is in the storage and subsequent read-out of data in a manner such as to obtain a set of values corresponding to the variables affecting the paper or other output product coming out of the machine at a particular time. This feature is important because of the time required for movement of a product or its constituents through a machine. For example, in a paper making machine, definite times are involved in moving pulp through a preparation section and movement of a web through a forming and press section and a drying and

winding section. Further important features of the invention relate to the provision of closed control loops for automatically maintaining certain parameters at certain values. This is 3)490)689 4 important in stabilizing operation but is even more important with respect to parameters found to have a directly controlling effect on the character of the paper or other output product. At the same time this feature has the ad- vantage of simplifying the operation of the automatic control system. SpecifiG features of the invention relate to the provision of closed control loops for maintaining the consistencies in pulp storage vats and in a mixing chest at certain values as controlled from the automatic control system. Another specific feature of the invention relates to a closed control loop for controling freeness in a machine chest. Another specific and very important feature relates to a control loop for automatic control of the slice between a headbox and the Fourdrinier wire, to obtain an opti- mum ratio of stock velocity to wire speed. Another specific feature of the invention relates to control loops for controlling vacuum in vacuum boxes and in a couch roll. A further specific feature of the invention relates to an automatic control loop for maintaining a set nip pressure between press rolls. Still another specific feature of the invention relates to a control loop for controlling the supply of steam to drying rous in a manner to control the amount of decrease of moisture content in the web as the web passes through the dryer section. Still further features of the invention relate to the provision of means for automatically performing an opti- mizing operation. Other and more specific objects, features and advantages will become more fully apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate a preferred embodiment and in which: FIGURE 1 is a schematic block diagram of a paper making machine control system constructed in accordance with the principles of this invention; FIGURE 2 is a schematic block diagram of pulp prepa- ration section of the system of FIGURE 1; FIGURE 3 is a schematic diagram of a forming and press section of the system of FIGURE 1; FIGURE 4 is a schematic diagram of a drying, calender and winding section of the system of FIGURE 1; FIGURE 5 is a schematic electrical diagram of a profit rate computer of the system of FIGURE 1; FIGURE 6 is a schematic diagram of a comparison, logic and control circuit of the system of FIGURE 1; FIGURE 7 is a schematic diagram of a comparison and control circuit of the circuit of FIGURE 6; FIGURE 8 is a schematic diagram of an appraising and logic circuit of the circuit of FIGURE 6; and FIGURE 9 is a schematic dia.- ram of a program circuit of the circuit of FIGURE 6. Referring to FIGURE 1, reference numeral 20 gen- erally designates an automatically controlled paper-making machine constructed according to the principles of this invention. In the machine 20, plup is supplied to a preparation section 21 which feeds stock to the headbox of a forming and press section 22, from which a web is fed to a drying and winding section 23. An automatic control system generally designated by reference numeral 24 is provided for performing various functions. This system records the values of variables and also records quality or performance values, it provides for the deter- mination of profit rate, and it provides for the adjustment of variables to obtain the highest possible profit rate while maintaining quality and performance values within specified limits. The system also provides for the logging of performance data for examination by an operator, and the recording of data on punched tape for subsequent computing and examination operations. An important feature of the system 24 is in the storage and subsequent read-out of data in a manner such as to obtain a set of values corresponding to the variables af-

OCR Scanned Text - LPAR (12): 7 may then be registered in the unit 61 and transferred to the storage section 58 along with data derived from the reproducer head unit 49 through the amplifier 54, scanner 56 and analog-to-digital convertOT 57. Preferably, thf, storage unit 58 comprises first and second sections, data being fed into the first section while the data previously stored th,-rein is transferred to the second section. Irt addition, it preferably includes means for registering the difference betwe-- n the data values stored in the two sections. With this arrangement, the results of one test may be logged by the typewriter 60, or registered on the punched tape, along with information as to the d@-viation of values from the previous test. Thus, for example, if the results of the tensile strength test are chan@ed to go outside the desired limits while at the same time there has been a certain change in only one variable, the operator can readily ascertain the cause of the changed results of the tensile strength test, and he can then make th-@ required adjustment in operation. Accordingly, the operator at certain times such as at the end of the winding of a roll may make required changes in variables in order to keep- performance values withiii desired limits and to improve the profit rate. If desired, the automatic optimizing operation of the comparison, logic and control circiiit 52 may be then reinstituted. In some cases, the operator may desire to change the prograrn of the changes in variables. In other cases, the operator may wish to temporarily discontinue the automatic optimizing operation and make manual changes in certain variables slich as in the plilp preparation section and wait to see what results are recorded from such changes. In this respect, it is to be noted that the operation of the system is very flexible and always subject to the manual override of the operator. When it appears desirable to do so for economic reasons or to obtain data as to production of other types and grades of paper, the operator may manually make changes to produce a different type and/or grade. The optimizing operations as above d2scribed may then be repeated as long as desired. Thereafter, of course, still other types and/or grades of paper may be produced with the optimizing operation being then repeated. Ultimately, sufficient data is accumulated and stored on the punched tap. from which the most profitable type or grade Of paper to be produced can be estimated. Computer techniques can, of course, be used in this connection. Ultimatel the most profitable type y and grade of paper may be computed and the operation of the machine may be aiitomatically shifted over to that type. The optimizing operation cari still be continued, to attempt to obtain even higher profit rates and superior performance. Referring now to FIGURE 2, the illustrated pulp preparation section 21 comprises a purchased pulp storage vat 70 to whicii pulp is supplied through a flow meter 71 and a broke pulp storage vat 72. to which pulp is supplied through flow meters 73 and 74, internal broke from the paper machine being applied through the flow meter 73 and broke from finishing operations being aPplied through the flow meter 74. T'he pulp flows from the purchased pulp storage vat 70 and the broke pulp storage vat 72 through flow meters 75 and 76 into a mixing chest 77. Ptilp from the mixing chest 77 flows through a flow meter 78 into a reflner 79 from which it flows to a m,,ichine chest 80. Pulp from the machine chest 80 flows through a flow meter 81 to the forming and press section, described hereinafter in conjunction with FIGURE 3. In addition to purchased and broke ptilp, color, size and alum may be supplied to the mixing chest from suppliers 82, 83 and 84 and throi-i,@h valves 85, 86 and 87 and flow meters 88, 89 and 90. Other additives may, of course, be supplied in similar fashion to the mixing chest 77. 3)490)689 8 Important features of the pulp preparation section reside in the provision of closed control loops for automatically maintaining certain parameters at certain values. This is important in stabilizing operation but is even more important in that it is found that such parameters have a directly

controlling effect on the characteristics of paper made by the machine and with the closed control loops, parameters are established which can be measi-ired and controlled to obtain optimum operation. Am addi- tional advantage is in the simplification of the operation of the automatic control of the system. In particular, closed control loops are provided for maintaining the consistencies in the vats 70 and 72 and in the mixing chest 77 at certain values. The closed con- trol loop for the purchased pulp vat 70 comprises a consistency measuring device or sensor 91, a !device known in the art which produces an electrical si.-nal proportional to consistency, a comparator circuit 92 which develops an error signal proportional to the dif- ference between the signal from the sensor 91 and a control signal applied on a line 93, a controller 94 which responds to the error si,-nal from the comparator circuit 92, and a valve 95 controlled by the controller 94 to con- trol the supply of water to the vat 70, the water bein@. applied to the valve 95 through a flow meter 96 connected to a main water line 97. Similarly, the control loop for the broke pulp vat 72 comprises a consistency sensor 99, a comparator circuit 100 responsive to the signal from the sensor 99 and a control signal on a line 101, a controller 102 and a water valve 103 controlled by the controller 102, the water valve 103 being connected through a flow meter 104 to the main water supply line 97. The control loop for the mixing chest 77 comprises a consistency sensor 105, a comparator circuit 106 which receives signals from the sensor 105 and from a control line 107, a controller 108 controlled by an error si.-nal from the comparator circuit 106 and a water valve 109 contro.Ued by the controller 108, valve 109 bein@ con- nected to the water supply line 97 through a flow'meter 110. Another very important closed control loop is provided for controllin the freeness in the machine chest 80. A freeness sens or III develops a signal correspond- ing to the freeness of the pulp in the machine chest $0. A comparator circuit 112 compares the signal from the sensor Ill with a control signal applied on a line 113 and develops an error si-nal which is applied to a controller 114 which contro@ls the position of the plu@ in the refiner 79. The freeness of the pulp is a function', in lar.@e part, of the plug position in the refiner 79. The refiner 79 is driven by an electric motor 115 connected throiigh a watt meter 116 to a suitable electrical power source. To record the signals developed by the various flow meters, the watt meter 116 and the various control si@ nals, as well as to apply the control signals, a series o'f electrical terminals 121-138 are respectively connected to the flow meter 71, the control line 93, the control line 101, the flow meter 74, the flow meter 73, the flow meter 104, the flow meter 76, the flow meter 96, the flow ineter 75, the flow meter 88, the flow meter 89, the flow meter 90, the control line 107, the flow meter 110, the flow meter 78, the watt meter 116, the control line 113 and the flow meter 81. Referring now to FIGURE 3, which illustrates the forming and press section 22, pulp from the machine chest 80 of the pulp preparation system 21 is supplied through a valve 140 to the inlet of a pump 141 which also receives white water from a wire pit 142. The outlet of the pump 141 is connected through a valve 143 to a headbox 144. A pressure is maintained in the head box 144 by means of a compressor 145 driven by a motor 146. The pulp flows from the head box 144 out through a

OCR Scanned Text - LPAR (14): 11 324902689 12 For connection of the section 23 to the recording, comptiting and control circuits, a terminal 265 is connected to the flow meter 238 while terminals 266-271 are connected to the lines 242, 264, 252, 255, 258 and 261. FIGURE 5 illustrates the circuit of the profit rate computer 51. In this circuit, signals are applied to sixteen in]iut terminals 281-296 proportional to the values of variables affecting profit, as developed or

applied to the paper machine in the manner as described above, and as subsequently recorded and reproduced to obtain appr,Dpriate time delays, such that the signals applied to the computer circuit at any given time correspond to the conditions affectid.@ a particular portion of the paper produced by the machine. In particular, the signals applied to the terminals 281-296 respectively correspond to purchased pulp flow, purchased pulp consistency, broke pulp flow, broke piilp consistency, mixing chest flow, mixing chest consistency, pump power, refiner power, dilution water, color, size, alum, paper machine power, paper machine steam, basis wei.aht and length. The illustrated comptiter circuit 51 serves to develop an AC output voltage at an output terminal 297 proportional to profit rate, the output signal being proportional to a DC si.- nal developed at a circuit point 298 which is converted to an AC signal by a chopper 299 and applied to the output terminal 297 throu.-h an AC amplifier 300. The DC signal at the circuit point 298 is the summation of a plurality of DC voltages, one of which is of one polarity and proportional to <u>production rate</u> and the others being of thD opposite polarity and PrOportional to various fixed and variable costs. In particular, a DC voltage proportional to <u>production rate</u> is developed at a potentiometer 301, between its movable contact and one end terminal thereof. To develop this signal, the end terminals of the potentiometer 301 are connected throu.-h a rectifying diode 302 to the output of an amplifier 303, a filter capacitor 304 being connected across the potentiometer 301. An AC voltage is applied to the input of the amplifier 303 proportional to the product of the basis weight signal at input terminal 295 and the length signal at input terminal 296. Terminal 295 is connected throtigh a precision potentiometer 305 to -round, the movable contact thereof being connected to the input of the amplifier 303. The movable contact of- potentiometer 305 is mechanically ganged to the movable contact of a potentiometer 306 connected between grotind and a terminal 307, connected to a suitable source of constant voltage. The movable contact of potentiometer 306 is connected to one input of a servo unit 308 having a second input connected to the input terminal 296. In operation, the servo unit 308 adjusts the movable contact of potentiometer 306 to a position such that the volta,@e between. the contact and ground is equal to the voltage applied to the inpiit terminal 296, proportional to length. The position of the movable contact of potentiometer 305 is simultaneotisly adjusted and as a result there is applied to the input of amplifier 303 a signal proportional to the product of the basis weight signal applied to terminal 295 and the len.-th signal applied to terminal 296. Thus a signal is produced at the output of amplifier 303 proportional to the amount of paper produced per unit time, and by adjustment of the potentiometer 301 according to the unit price or value of the paper, a DC voltage is developed at the potentiometer 301 proportional to the money <u>value of the production</u> per unit time. To produce voltages proportional to the cost rate of items which remain fixed for substantial periods of time, a series of five potentiometers 311-315 are connected to batteries 316-320, or other constant voltage sources, each potentiometer being operative to develop an adjustable voltage between its movable contact and one end terminal thereof, with such adjustable voltages bein- applied in series relation to the voltace developed by POtentionieter 301, but of opposite polarity. The potentiometers 311-315 may be manually adjusted accord-ing to the cost per unit time of <u>overhead cost, depreciation, fixed labor costs, variable labor costs,</u> and heating. Other costs may be introduced in similar fashion. To produce voltages proportional to the variable signals applied to the input terminals 287-294, another series of potentiometers 321-328 are connected through rectffying diodes 329-336 to the outputs of amplifiers 337-344 having inputs connected to the terminals 287294, filter capacitors 345-352 being connected across the 10 potentiometers 321-328.

Each of the potentiometers 321328 is adjusted to produce between its movable contact and one end terminal thereof a DC voltage proportional to the cost rate of the variable related to the corresponding input terminal. For example, the signal applied to the input terminal 287 may be proportional to the power consumed in driving the pumps,. in kilowatts, and the potentiometer 321 may be adjusted according to the cost of a kilowatt hoiir of electricity. Additio.nal potentiometers 353 and 354 are provided for developing signals proportional to the value or cost rate of purchased and broke pulp, these potentiometers being connected through rectifying diodes 355 and 356 to the outputs of amplifiers 357 and 358, filter capacitors 359 and 360 being connected across the potentiometers 353 and 354. The consumption of purchased and broke pulp, as related to a particular portion of paper produced by the machine, is not directly produced by sensing devices, and it is necessary to perform certain computer operations in order to produce such signals. In particular, the flow of purchased pulp as related to a particular portion of paper produced by the machine is proportional to the product of (1) the flow measured by meter 75 at a certain time, (2) the consistency in the vat 70 as measured by the signal applied on line 93 at said certain time, (3) the flow from the mixing chest as measured by the meter 78 at a later time, and (4) the consistency in the mixing chest as determined by the sig- nal on line 107 at said later time, and is inversely propor- tional to the sum of two products, the first product being the products of values (1) and (2) above and the second product being the product of (5) the flow from the broke pulp storage vat as measured by the meter 76 at said certain time and (6) the consistency in the vat 72 as measured by the signal applied on line 101 at said certain time. The flow of broke pulp is determined in a sim- ilar fashion, values (5) and (6) being substituted for values (1) and (2) in the above expression. The purchased pulp input terminal 281 is connected through a potentiometer 361 to ground, the movable con- tact of potentiometer 361 being connected through a potentiometer 362 to around, and the movable contact of potentiometer 362 being connected through a potentiometer 363 to -round, the movable contact of potentiometer 363 bein.- connected to the input of amplified 357. Similarly, the broke pulp flow input terminal 283 is connected through a potentiometer 364 to ground, the rnovable contact of potentiometer 364 being connected through a potentiometer 365 to ground, the contact of potentiometer 365 being through a potentiometer 366 to ground, and the contact of potentiometer 366 being connected to the input of amplifier 358. The contact of potentiometer 361 is mechanically ganged to the contact of a potentiometer 367 connected between ground and terminal 368 to which a reference voltage is applied, the contact of potentiometer 367 being connected to one input of a servo unit 369 with the other input of the servo 369 being connected to the input terminal 282. With this arrangement, the contacts of potentiometers 361, 367 are automatically adjusted to a position corresponding to the magnitude of the purchased -pulp consistency signal applied to input terminal 282 and the signal at the contact of potentiometer 361 is proportional to the product of purchased pulp flow and purchased pulp consistency. In a similar manner, the contact of potentiometer 364

OCR Scanned Text - LPAR (15): 314902689 13 is ganged to the contact of a potentiometer 370 connected between ground and a terminal 371 to which a reference voltage is applied, the contact of potentiometer 370 being connected to one input of a servo unit 372 with a sec- ond input of the servo unit 372 being connected to the input terminal 284. With this arrangement a signal is developed at the contact of potentiometer 364 proportional to the product of broke pulp flow and broke pulp consistency. The signals developed at the contacts of potentiometers 361 and 364

are applied to the potentiometers 362 and 365 and are also applied to an addition circuit 373 which applies a signal to one input of a servo unit 374 having a second input connected to the contact of a - potentiom- eter 375 connected between ground and a terminal 376 to which a reference voltage is a-pplied. The servo unit 374 is mechanically connected to the contacts of po- tentiometers 362, 365 and 375 which are ganged together. In operation, the contacts of potentiometers 362 and 365 are moved to positions corresponding to the signal aP- plied from the addition circuit 373, but in inverse rela- tion, i.e., with the output-to-input voltage ratios of the potentiometers 362 and 365 being changed in inverse pro- portion to the voltage applied from the addition circuit 373. The contacts of potentiometers 363 and 366 are me- chanically ganged together and to the contact of a Po- tentiometer 377 connected between ground and a terminal 378 to which a reference voltage is applied, the contact of potentiometer 377 being inechanically connected to a servo tinit 379 and being electrically connected to one input thereof. The other input of the servo unit 379 is connected to the contact of a potentiometer 380 con- nected between ground and the mixing chest flow input terminal 285. The contact of potentiometer 380 is me- chanically -anged to the contact of a potentiometer 381 connected between ground and a terminal 382 to which a reference voltage is applied. The contact of the potenti- ometer 381 is connected to one in t of a servo unit I PU having a second input connected to the mixing chest con- sistency input terminal 286. In operation, a voltage is developed at the contact.of potentiometer 380 proportional to the product of mixing chest flow and mixing chest consistency and this signal through the operation of the servo unit 379 and the Po- tentiometer 377 controls the positions of the contacts of potentiometers 363 and 366 so that the output-to-input volta-e ratios of the potentiometers 363 and 366 are pro- portional to the product of mixing chest flow and mixing chest consistency. Accordingly, the required multiplying and dividing operations are performed and signals are applied to the amplifiers 357 and 359 proportional to purchased pulp flow and broke pulp flow, as they affect a particular por- tion of paper coming from the machine. The potentiom- eters 353 and 354 are adjusted in accordance with ian evaluation of the worth of purchased and broke pulp. Thus a DC voltage is developed at the circuit point 298 proportional to the profit rate. This voltage may be measured by a meter 384 and is converted by the choPPer 299 to an AC voltage which is applied th@rough the ampli- fier 300 to the output terminal 297. The output signal is applied through the line 53 to the multi-channel amplifier and is recorded on the tap 38, to be picked up by a re- producing head of the unit 48 and, with a delay, by the head of the unit 49. Such signals from the reproducing heads are applied through channels of the amplifiers 50 and 54 to the comparison, logic and control circuit 52. . Referring now to FIGURE 6, the comparison, logic and control circuit 52 develops output voltages on lines 391-400, which are connected through the cable 55 to terminals 122, 123, 133, 137, 205, 209, 210, 211, 212 anct 266 of the paper machine sections, to control purchased pulp consistency, broke pulp consistency, mixing chest consistency, freeness, stock-wire speed ratio, paper 14 machine speed, suction box vacuum, couch vacuum, nip pressure and moisture differential. The output lines 391400 are connected to- comparison and control circuits 401-410 which are connected to an appraising and logic circuit 411 and to a program circuit 412 ' In general, the appraising and logic circuit 411 determines whether overall performance has been increased or decreased, and supplies signals to the circuits 401- 410 to effect changes in the proper variables. A signal is applied on line 413 if overall performance has been increased and on a line 414 if overall performance has been decreased. Line 413 may be referred to as a "same" line, to indicate that

a variable should be changed in the same direction if a change thereof ha's produced an increase in overall performance. Similarly, the line 414 may be referred to as a "opposite" line. The program circuit 412 functions to make changes in selected variables iii a certain programmed sequence. FIGURE 7 is a schematic diagram of the comparison and control circuit 401, the other comparison and control circuits 402-410 being the same. In the circuit 401, the output line 391 is connected to the movable contact of a potentiometer 415 connected between ground and a terminal 416 to which a constant reference voltage may be applied, the, position of the contact being thus determinative of the voltage of line 391 which voltage is applied to the comparator circuit 92 of the pulp or preparation system of FIGURE 2, to control consistency in the purchased pulp storage vat 70. This control voltage may be indicated by a suitable volt meter 417. The position of the contact of potentiometer 415 is controlled by a reversible motor 418 having a grounded terminal 419, a terminal 420 to which a voltage may be applied to energize the motor in one direction and a terminal 421 to which a voltage may be applied to energize the motor in the reverse direction. To energize the motor 418 in response to signals from th gram circuit 412, the motor terminals 420 and e pro 421 are connected through contacts 422 and 423 of relays 424 and 425 to a terminal 426 to which a suitable supply voltage is applied. The relays 424 and 425 are connected between ground and terminals 427 and 428 connected to the program circuit. Thus upon application of a signal to terminal 427 to energize the relay 424, the contact 422 is closed to energize the motor 418 in one direction and thereby adjust the position of the contact of the potentiometer 415 to adjust the voltage on the line 391. The motor terminal 420 is also connected through a normally closed contact 429 of a relay 430 to contacts 431 and 432 of a differential relay having coils 433 and 434 controllin- a pair of movable contacts 435 and 436. Similarly, the'terminal 421 of motor 418 is connected through the normally closed contact 437 of a relay 438 to contacts 439 and 440 of the differential relay. The contacts 435 and 436 of the diffetential relay are connected to terminals 441 and 442 which are respectively connected to the same and opposite lines 413 and 414 from the appraising and logic circiiit 411. Terminals of the coils of relays 430 and 438 are connected together and to one terminal 443 of the comparator circuit 444 with the other terminals of the coils of the relays 430 and 438 being connected to terminals 445 and 446 of the- comparator circuit 444. The comparator circuit has one input terminal 447 connected through an amplifier 448 to the output line. 391 and a second input teiminal 449 connected tbrough an amplifier 1450 to an input terminal 451. Terminals of the differential relay coils 433 and 434 are connected together and to one terminal 452 of a comparator circuit 453 with the other termi,als of the coils 433 and 434 being connerted to terminals 45'4 and 455 of the comparator circuit 453. Comparator circuit 453 has one input terminal 456 connected through the amplifier 450 to the input terminal 451 and a second input terminal 457 connected through ;an amplifier 458 to an input terminal 459.

OCR Scanned Text - LPAR (16): 15 Input terminal 451 is connected to an output of the multi-channcl amplifier 50 to receive a signal equal to the value of the purchased pulp consistency si-nal on line 93 connected to the outplit line 391 at son-ic earlier time. Input terminal 459 is connected to an output of the multi-channel amplifier 54 to receive a signal equal to the value purchased pulp consistency signal at a still earlier time. Thus the input to the line 451 may be referred to as the latest recorded value of purchased pulp consistency while the input of line 459 may be referred to as the earlier recorded value of purchased pulp consistency. The signal on the output line 391

represents, of course, the present value of purchased pulp consistency. In explaining the operation of the circuit of FIGURE 7, it may be assumed that the appraising and logic circiiit 411 determines that there has been improvement in overall performance and that a signal is developed on the same line 413 connected to input terminal 441 of the circuit 401 and to the movable contact 435 of the differential relay. If at this time the latest Tecorded value Of purchased pulp consistency, on line 451, is greater than the earlier recorded value, on line 459, the comparator circuit 453 energizes the coil 433 of the differential relay to enga,-e contact 435 with contact 431 and to thereby apply a signal to the terminal 420 of the motor 418. Th-- motor 418 then operates the contact of the potentiometer 415 in a direction to increase the voltage on the output line 391. When this voltage exceeds the latest recorded value of the purchased pulp consistency signal at input terminal 451 by a certain amount, the comparator circuit 444 ener.-izes the relay 430 to open the contact 429 thereof and deener,@ize a motor 418. Similarly, if a signal is applied on the same line 413 to be applied to the movable contact 435 of the differential relay and if the latest recorded value of purchased pulp consistency is less than the earlier recorded value, the comparator circiiit 453 will energize the coil 434 of the differential relay to en-age contact 435 with contact 439 and to thereby apply a si.-nal to the terminal 421 of the motor 418, which will then hold the contact of the potentiometer 415 in a direction to decrease the output voltage on line 391. Then after the output voltage is. decreased by a certain amount in comparison to the latest recorded value of purchased pulp consistency, the comparator 444 will energize the relay 438 to open the contact 437 and deenergize the motor. It will be appreciated that a similar type of operation takes place when the appraisin.- and logic circuit 411 applies a si,@nal on the opposite line 414 on which signal is applied from the movable contact 436 of the differential relay to energize the motor 418 in one direction or the other. It is noted that the comparator circuit 444 in conjunction with the relays 430 and 438 functions to limit the amolint of increase or decrease of the otitput voltage with respect to the latest recorded value of the corresponding signal. It also insures against further increases or decreases in the output voltage in the event that chan,@es have been previously introdiiced manlially or by the program circuit 412. FIGURE 8 is a schematic dia-ram of the apprais' and logic circuit 411 which receives the latest recorded signals froni the multi-channel amplifier 50 and the earlier recorded signals from the multi-channel amplifier 54, correspondin,@ to the output of the profit rate computer 51 into the performance value si,-nals from the gloss sensor 251, the mo-isture sensor 254, the basis weight sensor 257 and the caliper sensor 260. The circuit 411 compares such latest and earlier recorded signals with each other and with reference signals of preset amplitudes and performs operations which may be summarized as follows: (1) If the latest ,ind earlier recorded performance value signals are within desired limits and if the latest profit rate signal is greater than the earlier profit rate 3)490,689 16 signal, then a signal is developed on the "same" output line 413. If, however, the latest recorded profit rate signal is less than the earlier recorded profit -rate signal, then a signal is developed on the "opposite" output line 414. (2) If one or more of the latest recorded performance value signals are beyond the desired limits, while the earlier recorded performance value sil-nals are within desired limits, a si@@nal is developed on the "opposite" output line 414 re.-ardless of whether the latest Tecorded profit rate signal is greater than the earlier recorded profit rate signal. (3) If one or more of the earlier recorded performance vallie signals are beyond desired limits, but the latest recorded perfo@-mance value signals are within desired limits, no si,-nal is developed on either of the output lines 413 or 414. (4) If most earlier and latest recorded performance value signals are beyond desired limits,

but the total deviation of the latest Tecorded performance value signals from desired values is greater than the total deviation of earlier recorded performance value signals from sucb values, a si,@nal is developed on the "opposite" line 414. On the other hand, if the the total deviation from the earlier recorded performance value signals to the latest recorded performance value signals is decreased, a signal is developed on the "same" output line 413. (5) If the latest and earlier recorded performance value signals are within desired limits and the latest and earlier recorded profit rate signals are the same, no sig- nal is developed on either of the output lines 413 or 414. However, change in certain variables may be arbitraiily made by the program circuit 412 to determine whether changes should be made in such variables. ne same operation may take place if the latest and earlier recorded performance value signals are beyond limits while the total deviation from desired values remains the same. In general the circuit 411 comprises comparator circuits and logical circuitry connected thereto to indicate whether (a) the latest recorded profit rate signal is greater or less than the earlier recorded profit rate signal, whether (b) the latest recorded performance value signals are within desired limits, and whether (e) the total deviation from desired limits of the latest recorded performance value signals is greater or less than that of the earlier recorded performance value signals. To develop a si.-nal which indicates whether the latest recorded profit rate signal is greater or less than the earlier recorded profit rate signal, a comparator circuit 460 is connected to the outputs of a pair of amplifiers 461 and 462 having inputs responsive to profit rate signals from channels of the amplifiers 50 and 54. The output of the comparator circuit 460 is applied to coils 463 and 464 of a differential relay 465 having a movable contact 466 movable upwardly to en-age a contact 467 or down- wardly to engage a contact 468, according to whether the latest recorded profit rate signal is greater or less than the earlier recorded profit rate signal. To develop a signal which indicates whether the latest recorded performance value signals meet the desired standards, four comparator circuits 471, 472, 473 and 474 are connected to the outputs of amplifiers 475, 476, 477 and 478 and also to four potentiometers 479, 480, 481 and 482, connected between ground and a terminal 483 which is connected to a suitable reference voltage source. The inputs of amplifiers 475-478 rcspond to the latest recorded signals corresponding to the outputs from the gloss sensor 251, the moisture sensor 254, the basis weight sensor 257, and the caliper sensor 260, while the potentiometers 479-482 are set manually according to desired performance values. The outputs of the comparators circuits 471-474 are applied to relays 485-488 having normally opened contacts connected between a terminal 489 and a line 490, terminal 489 being also connected to the contact 466 of the differential relay 465, The DC signal is applied to the

OCR Scanned Text - LPAR (17): 374902689 17 terminal 489 at predeterinined times or continuously to cause operation of the controller circuitry. The contacts of the relays 485-488 are closed when the latest recorded performaiice value signals differ by a certain amount from desired values, as set by the potentiometers 479-482. To develop a signal indicating whether the overall difference between desired values and the latest recorded performance value signals is -reater or less than the total difference between the desired values and the earlier recorded performance value signals, output si-nals from the comparator circuits 471-474 are applied through isolation amplifiers 491-494 to diode-capacitor rectifier circuits cbnnected in series, a DC signal being thereby developed which indicates the total deviation from desired values of the latest recorded performance value signals. The DC si,@nal so developed is applied to a comparator circuit 495.

In addition, comparator circuits 497, 498, 499 and 500 ,ire connected to the outputs of amplifiers 501, 502, 503 and 504, havin., inputs responsive to the earlier recorded performance value si.-nals corresponding to the outputs of the -loss sensor circuit 251, the moisture sensor circuit 254, the basis wei.-ht sensor circuit 257 and the caliper s- .nsor circuit 260. The comparator circuits 497-500 also have inputs connected to the potentiometers 479-482. The outputs of the comparator circuits 497-500 are applied throu.-h isolation amplifiers 505-508 to diode-capacitor rectifier circuits which are connected in series and to a second inpiit of the comparator circuit 495. Comparator circuit 495 has an output connected to coils 511 and 512 of a differential relay 513 having a movable contact 514 connected to the terminal 489 and movable iipwardly to engage a contact 515 or downwardly to engage a contact 516, according to whether the total deviation with respect to the latest recorded signals 's ,-reater or less than the total deviation with respect to the earlier recorded signals. The circuit 411 includes logical circuitry in the form of AND/OR gates and inverter circuits, and such circuitry may be best described with reference to the various POssible conditions of operation as follows: (1) If both the latest and earlier recorded performance value signals are within desired limits, the contacts of relays 485-488 and the contact 514 of relay 513 will be open and with the absence of a signal on the line 490, a signal is developed at the output of an inverter 520 to enable AND gate 521. If the latest recorded profit rate signal is greater than the earlier recorded profit rate Signal, the contact 466 is moved upwardly to enga,@e the contact 467 and apply a si-nal from the terminal 489 through the AND gate 521 . to the "same" line 413. If, however, the latest recorded profit rate signal is less than the earlier recorded profit rate si@nal, the contact 466 is moved downwardly to engage the contact 468 and to apply a si-nal from the terminal 489 through an AND gate 522 to the output "opposite" line 414, the AND gate 522 bein@ enabled by the signal applied from the inverter 520. (2) If the earlier recorded performance value signals are within desired limits, but one or more of the latest recorded performance value signals are beyond desired limits, the contact 514 is moved upwardly to engage the contact 515 and to enable a gate.523, a signal being then applied from the line 490 throu,,h the gate 523 to the "opposite" line 414. (3) If one or more of the earlier record-d performance value signals are beyond limits, but the latest recorded performance value signals are within limits, the contact 514 is moved upwardly to enable the gate 523, but with no signal applied on the line 490, no signal will be applied to the "opposite" line 413. (4) If both the earlier and latest recorded performance value si-,nals are beyond desired limits and the total deviation of the latest recorded signals is greaier than the earlier recorded signals, the contact 514 is moved upwardly to enable the gate 523 and a si.-nal is applied from is the line 490 through the gate 523 to the "opposite" line 414. If, however, the total deviation of the latest recorded signals is less than the total deviation of the earlier recorded signals, the contact 514 is moved downwardly to engage the contact 516 to enable a gate 524 and a signal is applied from the line 490 through the gate 524 to the "same" line 413. (5) The operation of the machin@- may become stabilized, with no output signal being developed on either of the lines 413 and 414. Under such conditions, the pro gram circuit 412 may be operated to automatically introduce changes in certain variables, and to initiate operation of the program circuit, a signal may be applied thereto from the appraising and logic circuit 411, through an output line 525. Line 525 is connected to an integrate or time delay circuit 526, requiring application of an input signal thereto for a certain time interval, before developing an output signal on the line 525. When the latest and earlier recorded profit rate signals are the same and when the performance value signals are within the selected limits, no signal is developed

at the output of an OR gate 527 connected to contacts 467 and 468 and to the line 490, and a si,-nal is developed at the output of an inverter 528 which is applied through an OR gate 529 to the integrate circuit 526. When such conditions exist for a c,-rtain length of time, depending upon the operation of the integrating circuit 526, a signal of a certain amplitude is developed on the output line 525. In addition, when the performance value signals lie out- side desired limits but without any difference in total deviation, no signal is applied through an OR gate 530 and an output signal from an inverter 531 is applied through an AND @ate 532 and through the OR gate 529 to the integrate circuit 526, and the AND gate 532 being en- abled by a si-nal on line 490. Shown in F-IGURE 9, the program circuit 412 has ten output terminals 541-550 which are connected to "increase" inputs of the control circuits 401-410, and ten terminals 551-560 connected to "decrease" inputs of the control circuits 401-410. For example, terminals 541 and 551 are respectfully connected to input terminals 427 and 428 of the control circuit 401 shown in FIGURE 7. Terminals 541-560 are selectively connected in any desired fashion to terminais 561-566, connected to termi- nals of a step switch 567 having a movable contact 568. The interconnection between terminals 541-560 and the terminals 561-566 may be made in any desired fashion, patch cords or the like being suitable, such that the interconnection therebetween may be chan,-ed as desired. As illustrated, the contact 568 is connected to terminal 561 which is connected to terminals 541, 544, 547, and 550, and increase signals would be applied to th-. purchase pulp consistency, freeness, suction box vacuum and mo;sture differential circuits. When the contact 568 is moved to a second position to be connected to terminal 562, it would then be connected to terminals 542, 547, and 548 to apply increase signals to the broke pulp consistency, stock-wire speed ratio and couch vacuum control circuits. The other connections between terminals 561-566 and terminals 541-560 will be obvious from inspection of FIGURE 9, it being understood that such interconnections may be changed as desired. The contact 568 of the step switch 567 is moved from one position to another by means of a switch operator 569 which has an input connected to a selector switch 570, to be controlled in one of three ways. As shown, selector switch 570 connects the input of switch operator 569 to the otitput line 525 from the appraising and logic circuit 441. In a second position of the selector switch 570, the input to the switch operator 569 is connected through a push button 571 to a terminal 572, to which a suitable voltage may be supplied, so that the switch operator 569 may be manually controlled by operation of the push button 571 ' In a third position of the selec- tor switch 570, the input to the switch operator 569 is

OCR Scanned Text - LPAR (18): 3)4907689 19 connected to a timer 573 which supplies a co-,itrol signal at predeterminated time intervals. A series of twenty push buttons 574 are also provided for applying an increase or decrease signal to any selected one of the control circuits, the push buttons 574 being connected between the terminals 541-560 and a terminal 575 to which a suitable volta-e is applied. Terminal 575 is also connected to the movable contact 568 of the step switch 567. The program circuit 412 permits a great deal of flex- ibility in applying chan.-C signals to the various control circuits. It is noted that although the illustrated system records and performs analog multiplying operations on the var- ious sensed signals, without conversion to digital si.-nals, it is also possible to convert the sensed signals to digital signals which may be recorded or stored and later read- out from storage to produce signals properly - correlated to the product produced by the system at a - particular time, using the same principle of operation as

utilized in the illuslrated system. The multiplying operations can then be performed di-itally. It will be tinderstood that other modifications and vai-iations may be effected without departing fi@om the spirit and scope of the novel concepts of this - invention. The invention claimed is: 1. An aiitomatic machine system for a macbine having i plurality of sections comprisin.- (a) means for detect- Ing and recording values of a plurality of variables in 3aid machine sections, (b) means for controlling said plurality of variables, (e) a compliter connected to receive inputs from said means for detectin- and recording ind connected to supply an input to said means for de- @ecting and recording, (d) a comparison and lo.-ic control receiving inputs from said means for detecting and record- @ng and connected to supply inputs to said means for con- ,rolling said variables, and (e) a storage means connected :o receive inputs from said means for detecting and re- ,ordin.- and connected to supply outputs to said compari- ;on and logic control. 2. An automatic system according to claim I wherein ;aid detecting and recording means includes magnetic :ape means and read-in and read-out magnetic heads. 3. An automatic machine system according to claim I ,omprising performance value means connected to suPPIY .nputs to said storage means. 4. An automatic machine system according to claim I -omprising means for recording the performance of said nachine system connected to said storage means. 5. An automatic machine system having a plurality)f closed loop servo systems comprising, (a) means for letecting and recording values of a plurality of variables in ;aid machine, (b) a computer connected to @receive inputs .rom said means for detecting and recording, (c) a com- or detecting and recording, (d) means for - controllmg ;aid variable forming parts of said closed loop servo sys- ems and receiving inputs from said comparison and ogic control, (e) a storage means connected to receive nputs from said means for detecting and recorcling and upplying outputs to said comparison and logic circuit, tnd (f) means for supplying performance values to said torage means such that the values of said variable may)e made optimum. 6. In an automatic paper making machine, a system for @ptimizing the consistency of pulp comprising, means for ensing the consistency of pulp in the machine, means for @dding fluid to the pulp in the machine to change the onsistency, means for detecting and recording values of onsistency connected to said sensing means, a compari- on and logic control receiving inputs from said detecting nd recording means and connected to supply inputs to aid means for adding fluid, a stora'ge means connected receive inputs frpm said detectiipg and recording means ,nd .pqts to said cuit and means for supplying performance value to said storage means. 7. In an automatic paper making machine, ia system for- optimizing the freeness of pulp in the machine comprising, means for sensing the freeness of pulp in said machine, a refiner which has a plug of variable positions, means for varying the position of said plug to change the freeness of the pulp, means for detectin.- and recording values of freeness of said pulp connected to said sensing means, a comparison and logic circuit receiving inputs from said detecting and recording means and connected to supply inputs to said means for varying the position of the plu.-I a storage means connected to receive inputs from said detecting and recording means and supplying inputs to said comparison and logic circuit, and means for supplying performance values to said storage means. 8. In an automatic paper making machine having a slice and a movable wire, a system for optimizing the position of the 8lice member comprising, means for sensing the speed of said wire and the pulp pressure in the machine, means for controlling the slice member of the machine, means for detecting and recording values of the position of said slice member connected to said sensing means, a- comparison and logic control receiving inputs from said detecting and recording means and connected to supply inputs to said

controlling means, a storage means connected to receive inputs from said detecting and recording means and supplying inputs to said comparison and lo.-ic circuit, and means for supplying performance value to said storage means. 9. In an automatic paper making machine having a vacutim box, a system for optimizing the pressure in said vacuum box comprising, means for sensing the pressure in said vacuum box, means for controlling the pressure in said vacuum box, means for detecting and recording values of the pressur'e in said vacuum box connected to said sensing means, a comparison and logic control receiving inputs from said detecting and recording means and connected to supply inputs to said controlling means, a stora,@e means connected to receive inputs from said detecting and recording means land supplying inptits to said comparison and logic circuit, and means for supplyiDg performance values to said storage means. 10. In an automatic paper making machine, a system for controleng the pressure between rolls comprising, means for sensing pressure between rolls in the machine, means for controlling the pressure between rohs in the machine, means for detecting and recording values of the pressure between the rolls connected to said sensing means, a comparison @and logic control -receiving inputs from said detecting and recording means and connected to supply inputs to said control means, a storage means connected to receive inputs from said detecting and recording means and supplying inputs to said comparison and logic circuit, and means for supplying performance values to said stor- @9M.@4riso and lo@ic cir- 7& mg4iqs fQr detecting and recordin y4lli(@5 gf MQistUre a 11. In an automatic paper making machine, a system for- controlling the drive shaft of the machine comprising, means for sensing the speed of the drive shaft in the machine, means for controlling the speed of the drive shaft of the machine, means for detecting and recording values of the speed of the drive shaft connected to said sensing means, a -comparison and logic control receiving inputs from said detecting and recording means and connected to supply iriputs to said control means, a storage means connected to receive inputs from said detecting and recording means land supplying inputs to said comparison and logic circuit, and means for supplyin@- performance values to said storage means. 12. In an automatic paper making machine, a system for- controlling the drying section comprising, means for sensing the moisture content of paper in the drying section of the machine, means for adding fluid to the drying section in the machine to change the moisture content,)arison and logic control receiving inputs from said means 55 ge means.

OCR Scanned Text - LPAR (19): 21 content connected to said sensing means, a comparison and logic control receiving inputs from said detecting and Xecording means and connected to supply inputs to said means for adding fluid, a storage means connected to receive inputs from said detecting and recording means and supplying inputs to said comparison and logic circuit, and means for supplying performance values to said storage means. References Cited UNITED STATES PATENTS 2,922,475 1/1960 Alexander ---------- 162-252 2,972,446 2/1960 White ------ ------- 235- 252 3)490)689 22 3,016,460 1/1962 Andresen -------- 235-151.32 3,044,701 7/1962 Kerstukos et al. ---- 235-150.1 3,048,331 8/1962 Van Nice et al ------- 235-151 3,260,838 7/19.66 Andresen -------- 235-151.13 5 MALCOLM A. MORRISON, Primary Examiner E. J. WISE, Assistant Examiner U.S. Cl. X.R. 10 162-252; 235-151.12, 151.34

US-PAT-NO: 3575798
DOCUMENT-IDENTIFIER: US 3575798 A
TITLE: PROCESS FOR MAINTAINING STEAM DRYER PRESSURE BELOW THE MAXIMUM AVAILABLE
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OCR Scanned Text - LPAR (2): 3 1 5 7 5 @ 7 9 8 United States Patent Office 20, 1971 1 2 3,575,798 PROCESS FOR MAINTAINLNG STEAM DRYER PRESSURE BELOW THE M, AXIMUIM AVAILABLE Erik B. Dah@lin, Saratoga, Calif., assignor to International Business M,,ichines Corporation, Armonk, N.Y. 5 Filed July 3, 1968, Ser. No. 742,318 int. Cl. D21f 5102 U.S. Cl. 162-198 3 Claims 10 ABSTRACT OF THE DISCLOSURE A method of controllin,@ a physical process, like a paper makin.- machine, is disclosed. The process has at least two variables. The first variable in the process is frequently adjusted. The second variable is less frequently i5 adjusted. The second variable is relatively stable. Setting the relatively stable variable establishes an operating range for the first variable. The measurable production from the physical process is thereby improved and/or increased. In a paper makin,@ machine, machine speed is 20 adjusted infrequently in response to the moisttire content of paper after a dryer section, to establish an operating ran-e for dryer steam pressure which is below the maxi- mum available steam pressure, the dryer steam pressure then bein.- adjtisted within the rar,.,e to correct for mois- 25 ture variations. CROSS REFERENCES TO RELATED APPLICATIONS 30 An invention described in U.S. patent application, Ser. No. 599,878, filed Dec. 7, 1966, now Pat. No. 3,534,400, by the same inventor and entitled "Parameter Iden-Lifica- tion Method For Process Control Systems" can be used 35 in conjunction with the invention of this application. The same is true of another invention described in earlier filed U.S. application, Ser. No. 599,879, filed Dec. 7, 1966 by the same inventor and entitled "Coefficient Tuning Methods For Process Control Systems." Both the noted 40 patent applications . are assi,@ned to the same assignee as this patent application. BACKGROUND OF THE INVENTION (1) Field of the invention 45 The invention relates to a method of controllina a phy sical process. More particularly, it relates to inereas- in@ the production rate, and the quality, of a paper mak in.- machine. (2) Descript,'@on of the prior art 50 This invention relates to the art involvin- paper makin,@ mac hines, particularly those that produce heavy paper, suc h as board or ba.@ paper. Such machines have been cha racterized in the past by "dryer-limited" operation. 55 This means that the production rate of the machine is limit ed by the machine's ability to dry the paper stock. The speed of the machine must be kept down so as to allo w the paper stock to be dried to the proper degree befo re exitin,@ from the dryer section of the machine. 60 Ste am filled rollers are used as dryers. The steam is freq uently supplied to such rollers in an unre@ulated man ner; that is, the rollers receive as mtich steam as the cent ral boiler can produce. In order to control the dryin,@ rate in such equipment, 65 the speed at Nvhich the paper passes over the dryer rolls (i.e. machine speed) is varied. Due to the mechanical natu re of the drive mechanism, this speed control oper- atio n h,,is generally been implemented at no less than fifte en minute intervals. Thus, should a measurement of 70 the paper's moisture content indicate that the dryin,@ rate is improper, it can be seen that paper of sub-standard quality can be produced for as much as fifteen rninutes before suitable control action is taken. Typical paper machine production rates are in the vicinity of tons of paper per hour. This means that a significant amount of below grade, or low quality, paper can be coming out of the

machine during a fifteen minute interval. Such paper must either be scrapped, or sold at a reduced price, thereby adversely affecting the entire operation of the particular paper mill in question. Accordingly, it is a general object of this invention to improve the art of controlling physical processes and particularly paper making processes. A more particular object of this invention is to exercise control action in a manner most efficient from the viewpoint of utilizing time; that is, adjust one manipulated variable infrequently so as to establish an operating range for another manipulated variable and then adjusting the last-mentioned variable frequently. A still more particular object of this invention is to improve the production rate of a paper making machine by controlling and adjusting machine speed less frequently than dryer pressure. SUMMARY OF THE INVENTION In accordance with one aspect of my invention, a method for controlling physical processes is disclosed. That method comprises the steps of adjusting one manipulated, and relatively stable, variable infrequently so as to establish an operating range for a frequently changed variable. The value of that variable is thereby optimized. The frequently changed variable performs a fine regulation role. The entire associated physical process, involving the rnanipulating of physical quantities and operating thereon in accordance with rules of thermodynamics, etc. . . Is 'mproved. In accordance with another aspect of my invention related specifically to paper making machines, the machine speed is repetitively measured. In addition, the moisture content of the paper is also repetitively measured along the length of the paper being formed. Further, the maximum available steam pressure for the dryers is measured. The machine speed is then adjusted so that it is at a suitable value in reference to a steam pressure of some increment less than the maximum pressure available. This setting of the dryer speed takes place every fifteen minutes or so. Then, adjustments are made to the steam pressure within the increment of steam presstire available. These adjustments refine the degree of drying effected, or implemented, by the paper machine. To contrast this invention with the prior art requires an understanding of the problem and earlier solutions. The problem of increasing the production rate of a paper machine, or any physical process for that matter, has been kngwn to the prior art. Various control schemes Lising one or another parameter, or even a plurality of parameters, adjustments have also been known to the prior art. The advantage of this invention lies in that it teaches a specific combination of adjustments to process variables that takes advanta-e of the characteristics of each variable. A variable, which is only adjusted infrequently, is set for most economical operation. An unstable variable, which by contrast is varied, or adjusted, frequently, keeps the stable variable within the most economical operating range. Exploring this more fully and looking specifically at paper makin- machines, the most typical approach to solving the dryer limited operating problem is simply to operate the paper making machine at maximum dryer steam pressure. That is, all the steam supplied by the boiler is forwarded to the dryers in an- unregulated manner. The machine speed is then adjusted every fifteen

OCR Scanned Text - LPAR (3): 3 minutes or so in accordance with the steam pressure then available to the dryers. As noted earlier, this means that si,-nificant amounts of paper of a lower than desirable quality may vell be produced. Alternatively, the prior ar-t has adjusted the steam supplied to the dryers. That is, some dryers have not operated at wide open steam pressures, but rather the steam supplied to them has been regulated. Nowhere in the prior art has there been a teaching of the combined steps involving adjusting the machine speed infrequently and the steam pressure frequently as is taught in this invention. T'his invention is particularly applicable to

implementation on an automated paper making machine. That paper making machine could be under the control of an IBM 1800 Process Control Computer, for example. The already improved operation resulting from such a control mode is enhanced by the method of this invention. However, the method of this invention could be practiced by hand if necessary or by combinations of analog and di.@ital equipment if necessary. The primary economic advantage from this invention is that the production rate of a paper machine is, in view of the dryer limited problem, increased to a practical upper limit. Below quality paper, as measured in tons, is significantly reduced over given time periods. The quality of product-ion bein.- maintained relatively constant over a long time period results iii increased profits for the owner and operator of the paper making machine so controlled. Accordingly, the foregoing and other objects, features and advanta,-es of the invention will be apparent from the fotlowing more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawin.-- BRIEF DESCRIPTION OF THE DRAWIING FIG. 1 is a block diagram of a generalized physical process being controlled according to the method of my invention. FIG. 2 is a block diagram of a paper making machine being controlled according to the method of my invention. DESC,RIPTION OF PREFERRED EMBODIMENT Both -FIGS. I and 2 will be used to describe a pre rre- embodiment of this invention. Before entering into that description, it should be noted that my invention includes a new method of interrelating measured and controlled variables in a process. It involves takin@ a series of physical measurements, performing certain mathematical operations, on the values obtained by these measurements, and then adjusting certain variables in accordance with the results obtained from the computation. Should a computer be utilized to perform the computation, the computer program is not my invention. My invention is a control technique, or more explicitly, my invention is a method of adjusting a setting of process variables in accordance with signals obtained from the process being controlled. With that as an introduction, FIG. 1 will be described. Process 10 in FIG. I receives an input of material 12 and generates an output of modified material 14. The material provided to process 10 from input 12 is operated upon by the process in accordance with certain rules of thermodynamics and kinetics, etc. For example, should it be a paper -making process, an input of water and pulp is cooked and dried until finished paper is formed. In that example, the finished paper is the output of modified material 14. A controller 16 can control identifiable variables present in process 10. In order to do this, it is necessary tO know the state of the variables. Sensor IS receives as a signal from process 10 on line 20 the value of a first variable. That value is represented by an electrical signal and forwarded on line 22 to controller 16. Simimarly, sensor 24 receives as an input from process 10 on line 355751798 4 26 a value, or measurement, of a second variable. That value is represented by an electrical signal on line 28 and forwarded to controller 16. Sensor 25 measures a property of the output of modified material 14 (a third variable. The valtie of that property is represented by an electrical signal on line 27 and forwarded to controller 16. Controller 16 evaluates the signals received on lines 22, 27, and 28 and decides whether or not the values of variables I and 2 are to be modified. If so, signals are forwarded on lines 30, 32 to process 10, and the values of variable I and variable 2 are modified in accordance with the si.-nals present on lines 30, 32. In a preferred embodiment of this invention, variable I could be a relatively stable variable and one that is in- frequently adjusted. Variable 2, by contrast, could be adjusted relatively frequently; that is, its value could change rapidly as a function of time. This being so, variable I would be adjtisted in response to a signal on line 30 relatively infrequently -when compared to the adjustment of variable 2 in

response to signals on line 32. This type of adjustment results in a smoothing operation on the output of modified material 14. The method of my invention will become clearer by reference to FIG. 2. There, a preferred embodiment ref- erencing a paper makin.- process is shown and described. A knowledge of paper making machines is assumed on the part of one skilled in this art. A description of such a machine can be found in McGraw-Hill Eneyclopedia of Science and Technology, vol. 4, p. 289-1960 edition and also in vol. 9 at p. 540 of th-, same encyclopedia. Thus, the apparatus shown in FIG. 2 is depicted schematically @and only elements pertinent to this invention are set forth. With reference then to FIG. 2, a mixture 200 of liquid and pulp is contained in head box 202. It is ejected through portal 204 as a spray and deposited upon endless belt 206. Belt 206 is driven by drive means 208, shown here as a motor driven roller @which must necessarily cooperate with an associated idler roller, or even another positive drive roller, 210. The mixture 200 of pulp and fluid thus deposited on endless belt 206 is formed into finished paper and wound on takeup reel 212. To convert the mixture 200 of pulp and fluid into paper, it is necessary to remove some of the fluid from that mixture. This is accomplished by dryer means 214, shown here as a conventional steam heated cylinder receiving steam from a boiler 216. (In actual practice, more than one cyliiider would be present.) To convert the mixture 200 of pulp and fluid into finished paper of certain characteristics requires the measurement and manipulation of many variables, only two of which are considered in the teachina of this invention; namely, machine speed and steam pre' sure. Machine speed can be measured in feet per unit Of s-time and the measurement is taken in relation to endless belt 206, while steam pressure can be expressed in the conventional units of pounds per square inch -auge or absolute. Controller 16 is also shown, as are sensors 18 and 24. Completing the description of the exemplary equipment set forth in FIG. 2, note the provision of a valve 218 in the steam supply line 219. To operate according to the principles of this invention, assume that the speed of drive roller 208, as @well as the setting of valve 218, have been established at some initial value. Sensor 18, which could be a moisture gauge, such as the "Moistron" gauge of Industrial Nucleonics, then begins to measure the moisture content of the paper leaving the dryer section. These measurements are trans- lated into electrical signals vvhich are relayed on line 22 to controller 16. Similarly, the value of steam pressure supplied to drum 214 is monitored by sensor 24 and those values are transmitted to controller 16 in the form of electrical signals on line 28. Equipment for sensing steam pressure and converting it to electrical si.-nals is cornmer- cially a- @,ailable from companies like Taylor Instruments or Leeds and Northrup. @CoDtroller 16 has stored within it a set point value for the maximum pressure available

OCR Scanned Text - LPAR (4): from boiler 216. It also has within it an algorithm expressing a relationship of average current steam pressure and machine speed for a particular paper quality. One such algorithm is set forth in Equation 1: (1) Speedn=speed,,-,+Al (maximum steam pres- sure-average current steam pressure+A2) where: iz=a given sampling time Al, A2 are constants. Havin- received these measurements on a continuin.basis from sensors 18, 24, controller 16 will adjust the machine speed every fifteen minutes or so. This adjustment is made by means of si.-nals on line 30 to a motor associated with drive means 208. The machine speed is so set that not all of the dryin.- effect available from dryer 214 is used; that is, a slight range for steam adjustment is left. However, by the algorithm (1), the controller sets the machine at the maximum speed possible un.der existin.- steam demand. Still, a fine moisture regulation, using

small- variations in the steam pressure, is available. More frequently, the controller 16 determines how the steam pressure should be varied within that range so as to maintain constant moisture contents in the sheet. Controller 16 does this by sensin- the pressure available from boiler 216 and making the necessary adjustments by means of signals on line 32 to valve 218. The follow' ing algorithm expresses the relationship between moisture content and steam pressure. (2) Press,@D, Press,-, +D2 PresS,1-2+El (mois- ture reference-moisture,,)+E2 (moisture reference-moisturen-1) whered,, D2, El, and E2 are constants. The following table gives an example of typical variable values in accordance with the teachings of my invention. Steam Moisture Speed, pressure, content, f.p.m. P.S.i.g. percent i@linutes: 15 ---------- 15,260 38.6 6.1 16 ---------- 15,296 45.2 6.1 17 ---------- 15,296 45.8 6.3 18 ---------- 15,296 45.1 6.1 19 ---------- 15,296 44.9 6.0 20 ---------- 15,296 45.2 6.1 While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that the fore.-oing and other changes .'n form and details may be made therein without departing from the spirit and scope of the invention. What is claimed is: il. A method of maintainin,@ the quality of paper produced by a paper making machine having a dryer section, means for controllin- dryer header steam pressure, and means for controlling machine speed, comprising the steps of: measurin.- moisture content of paper stock at a predetermined point after said dryer section in said machine to provide a signal indication of said mois- ture content thereat; .1 providing a signal indication of the maximum avai able steam pressure for said dryer; adjustin- in response to said si.-nal indication of maximum available steam pressure, said machine speed at predetermined infrequent intervals to a value estimated to require dryer header steam pressure a predetermined deviation less than said maximum available steam pressure, thereby establishing an operat- 2)575)798 6 ing range for adjustment of said dryer header steam pressure; comparing said moisture content signal to a predetermined indication of desired moisture content to pro- vide an error signal; and adjusting, in response to said error signal, said dryer header steam pressure at predetermined frequent intervals such that a plurality of said frequent intervals are included within each of said infrequent intervals, such adjustment being in a direction to cause the reduction of said error signal to zero. 2. The method of claim I wherein said step of adjust- ing machine speed additionally comprises: periodically measuring said dryer header steam pres- I ra sure to provide signal indications thereof; avera.-ing said signal indications of dryer header steam pressure over a preceding time interval of fixed duration to provide a signal indication of the average current header steam pressure; subtracting said signal indication of averaged header pressure from said signal indication of maximum available steam pressure and a constant value to generate an error term signal, said constant value rep- resenting said predetermined deviation; and adjusting said machine speed at said predetermined infrequent intervals in response to said error term si@@nal in a direction and of a value to cause the reduction of said error term signal to zero. 3. The method of claim I wherein said step of adjusting machine speed comprises: periodically measuring said dryer header steam pressure to provide signal indications thereof; averaging said signal indications of dryer header steam pressure over a preceding time interval of fixed dura- tion to provide a signal indication of the average current steam pressure; and generating a speed control signal to operate said speed control in response to said signal indications of maxi- mum available steam pressure and of average current steam pressure at said predetermined infrequent intervals in accordance with the following algorithm: speedn=speed,,-,+Al (maximum steam pressureaverage current steam pressure +A2) where n= a given sampling time; Al=a predetermined constant

relating steam pressure to machine speed for a vine desired paper; A2=a constant representing said predetermined devia- tion of dryer header pressure below the maximum available steam pressure. References Cited UNITED STATES PATENTS 3,490,689 1/1970 Hart et al - -------- 162-252X 1 626,060 4/1927 Witham, Jr - --- ---- 162-263X 1:926,292 9/1933 Kruse -------------- 162-198 3, 073,153 1/ 1963 P etitjean -- -------- 1 62-263X 3, 260,642 7/ 1966 C anter, Jr - -------- 1 62-263X OTHER REFERENCES "Pulp And Paper Mantifacture," vol. 4, "Auxiliary Paper Mill Equipment," McGraw-Hill, 1955, p. 217-219. S. LEON BASHORE, Primary Examiner A. D'ANDREA, JR. Assistant Examiner U.S. Cl. X.R. 162-@253, 256, 263

US-PAT-NO: 4893250
DOCUMENT-IDENTIFIER: US 4893250 A
TITLE: Centralized loom control method with optimization of operating speed
DATE-ISSUED: January 9, 1990
INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Sainen; Tsutomu	Kanazawa	N/A	N/A	JP

US-CL-CURRENT: 700/140, 139/1R

ABSTRACT: A centralized loom control method employing a host computer for controlling the operation of a plurality of looms. Data base including data accumulated by recording past actual weaving conditions in stored in a memory device connected to the host computer. The host computer determines standard set value for which the looms are to be set by processing the specifications of a fabric to be woven entered therein and data fetched from the memory device through predetermined calculation or interpolation. The host computer compares a standard operating speed among the standard set values with a target operating speed at which the loom is to be operated, and changes the standard set values according to the result of comparison to provide new standard set values suitable for operation at the target operating speed.
3 Claims, 19 Drawing figures
Exemplary Claim Number: 1
Number of Drawing Sheets: 10

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Abstract Text - ABTX (1): A centralized loom control method employing a host computer for controlling the operation of a plurality of looms. Data base including data accumulated by recording past actual weaving conditions in stored in a memory device connected to the host computer. The host computer determines standard set value for which the looms are to be set by processing the specifications of a fabric to be woven entered therein and data fetched from the memory device through predetermined calculation or interpolation. The host computer compares a standard operating speed among the standard set values with a target operating speed at which the loom is to be operated, and changes the standard set values according to the result of comparison to provide new standard set values suitable for operation at the target operating speed.

Brief Summary Text - BSTX (11): In one aspect of the present invention, data accumulated in the past is stored in a memory device incorporated into a host computer for controlling a plurality of looms, standard set values are, divided by processing the data fetched from the memory device and data representing the specifications of a fabric through a predetermined operation or an interpolative operation, and a standard operating speed and a previously entered target operating speed are compared to decide new standard set values suitable for operation at the target operating speed. Then, data obtained by monitoring the operation of the loom controlled on the basis of the new standard set values and a plurality of standard values for the optimum control of the loom are compared in order of priority of the standard values, and then the standard set values are corrected on the basis of the result of comparison.

Brief Summary Text - BSTX (13): Particularly, since standard set values suitable for operation at a target operating speed stored previously in the host computer are decided, the standard set values are corrected to provide new standard set values and the loom is set for the new standard set values, the loom is not set for an operating speed excessively lower than the possible operating speed of the loom. Consequently, the loom operates for weaving at an ideal operating speed meeting the performance thereof. Thus, the advancement of weaving techniques is reflected on setting the operating speed of the loom, so that the productivity of the loom is improved.

Detailed Description Text - DETX (2): Referring to FIG. 1 showing a centralized loom controller for carrying out a centralized loom control method of the present invention, the centralized loom controller comprises, as principal components, a fabric data input means 1 for entering data representing the specifications of a fabric, a data base storage means 2 for storing a data base constructed by accumulating actual data obtained by recording data obtained by monitoring past actual weaving operation for fabrics of various kind, a set value calculating means 3 for processing fabric specifications entered by the fabric data input means 1 and actual data fetched from the data base storage means 2 through a predetermined operation to provide standard set values, a set value storage means 4 for storing new standard set values obtained on the basic of standard set values calculated by the set value calculating means 3 so as to meet a weaving operation at a target operating speed, a set value transmitting means 5 for transmitting the new set values to a plurality of loop control units 8 through transmitter-receiver means 81 connected respectively to the loom control units 8, an actual data receiving means 6 for receiving data representing the respective operating conditions of the looms and transmitted thereto through the transmitter-receiver means 81, and a set value changing means 7 for changing the standard set values stored in the set value storage means 4 on the basis of the actual data received by the actual data receiving means 6.

Detailed Description Text - DETX (3): The centralized loom controller further comprises a target operating speed input means 41 and a set value correcting means 42. The set value correcting means 42 is connected to the data base storage means 2, the set value calculating means 3, the set value storage means 4 and the target operating speed input means 41. The set value correcting means 42 decides new set values appropriate for weaving operation at a target operating speed by correcting the standard set values calculated by the set value calculating means 3, and then gives the new set values to the standard set value storage means 4.

Detailed Description Text - DETX (16): where .DELTA..theta.(degree)=360.times..DELTA.R.times..DELTA.T (sec), C is correction. The pressure is determined by defining the relation between standard pressure P and rotating speed R by a regression function and correcting the standard pressure P by P=k.times.R+P.sub.0. Other standard set values to be corrected according to the operating speed other than those relating to picking conditions, such as stop signal output phase, are corrected by a similar procedure. Thus, the standard set values are corrected in steps 10 through 14. Then, in steps 15 and 16, the host computer 9 gives sequentially control signals representing the corrected standard set values through the communication interface 12 and the bilateral bus 13 to the loom control unit 8 of the loom assigned to weaving the fabric.

Detailed Description Text - DETX (23): Suppose that the operating rate of the loom is excessively lower than the reference operating rate, i.e., a reference value having the highest priority, owing to highly frequent stoppage of the loom due to warp breakage, that is, a decision in step 1 is negative and a decision in step 2 is affirmative. Then, in steps 3 through 7, the standard set values of total warp tension having the third priority is reduced to a value not less than the lower limit of total warp tension. If the actual operating rate still falls short of the reference operating rete, the reference operating speed, i.e., a reference value having the second priority, is lowered to a value not less than the lower limit of operating speed in steps 8 through 11.

Detailed Description Text - DETX (24): When the operating rate of the loom is excessively lower than the reference operating rate owing to highly frequent stoppage of the loom due to faulty picking, that is, when both the decisions in steps 1 and 2 are negative, the reference pressure of the picking fluid, i.e., a reference value having the fourth priority, is increased to a value less than the upper limit of the pressure in steps 12 through 16, and then the reference total warp tension, i.e., a reference value having the third priority, is reduced to a value not less than the lower limit of total warp tension in steps 17 through 20 and 16. If the operating rate still falls short of the reference operating rate, the operating speed having the second priority is lowered further to a value not less than the lower limit in steps 21 through 24 and 16.

Detailed Description Text - DETX (25): On the contrary, when the operating rate is very high, namely, when the decision in step 1 is affirmative, the operating speed and the total warp tension are increased to values which will not reduce the operating rate below the lower limit of the reference operating rate in steps 25 through 33. When the loom is still able to operate without trouble, the reference pressure is decreased in steps 34 through 37 and 29. In steps 30 to 33, the choice of either the upper limit or the lower limit as the optimum value is decided in entering the reference value in the host computer 9. In this embodiment, the upper limit of the reference total warp tension is chosen as an optimum value.

Claims Text - CLTX (7): comparing a standard operating speed among the standard set values with a target operating speed of a loom on which the fabric is to be woven and changing the standard set values according to the result of comparison for a new standard set values suitable for weaving operation at the target operating speed; and

US-PAT-NO: 5034897
DOCUMENT-IDENTIFIER: US 5034897 A
TITLE: Optimum loom control method
DATE-ISSUED: July 23, 1991
INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Sainen; Tsutomu	Kanazawa	N/A	N/A	JP

US-CL-CURRENT: 700/140, 139/1R , 139/435.2

ABSTRACT: An optimum loom control method controls a loom so that the overall profit of a weaving mill is maximized. A profit evaluation function defining a profit evaluation valve includes variables including those affecting the profit of the weaving mill, such as information on the quality of fabric woven, the number of effective picks representing the quantity of fabric produced, and the energy consumption of the loom. A controlled factor or factors corresponding to a controllable variable or variables from among those of the profit evaluation function, namely, the operating speed of the loom, the pressure of the picking fluid or both the operating speed of the loom and the pressure of the picking fluid, are controlled so that the profit evaluation value is increased to a maximum.
4 Claims, 12 Drawing figures
Exemplary Claim Number: 1
Number of Drawing Sheets: 8

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Brief Summary Text - BSTX (38): Thus, the optimum loom control method raises the operating speed of the loom to the highest possible extent only when at least one of the control parameters has allowance with respect to the corresponding reference value, so that the production rate of the loom is enhanced without deteriorating any one of the control parameters.

Drawing Description Text - DRTX (8): FIGS. 7(A), 7(B) and 7(C) are graphs of assistance in explaining the variation of a profit evaluation value with the operating speed of the loom for the pressure of the picking fluid;

Detailed Description Text - DETX (4): In a predetermined period of time after the start of the loom, data indicating the operating mode of the loom including the ratio q of acceptable fabric, the operating rate .eta. of the loom and the unit energy cost C is collected, and then the value b of the profit evaluation value is calculated by using the profit evaluation function on the basis of the collected data. Then, the operating speed and/or the pressure of the picking fluid is increased or decreased while the loom is operating so as to enhance the profit evaluation value. The operating speed n is increased or decreased by a fixed value .DELTA.n and the pressure p is increased or decreased by a fixed value .DELTA.p in one control cycle. Since the reliability of data obtained by measuring the operating conditions of a single loom is unsatisfactory, it is advantageous to use data obtained by processing data obtained by measuring the operating conditions of a group of a plurality looms set for weaving the same kind of fabric by a host

computer for centralized control from the viewpoint of reliability of the data.

Detailed Description Text - DETX (7): During the foregoing process of optimum loom control operation, it is possible that the loom becomes unable to continue a weaving operation due to problems in the quality of the fabric when a long time is required for setting the loom for an optimum weaving condition, for example, for feeding back the results of an inspection of the fabric. In such a case, the operator may give an instruction to the computer to interrupt the evaluating operation or to restart an evaluating operation of a different mode in which an operating speed giving a maximum profit evaluation value is changed at a reduced operating speed changing step size.

Detailed Description Text - DETX (8): For the same reason, it is advantageous from the viewpoint of avoiding an ineffective control operation to stop changing the operating speed in the same direction when the profit evaluation value b decreases beyond a lower limit or when each factor changes beyond a limit value. Such a control operation may be applied in different modes individually to the looms in view of differences in performance between the looms to enable the individual production management of each loom.

Detailed Description Text - DETX (10): (1) Calculation of the profit evaluation value b and the decision of the operating speed n and the pressure p of the picking fluid are performed by the host computer.

Detailed Description Text - DETX (12): Referring to FIG. 1 showing a series of steps of control procedure for controlling a loom by the optimum loom control method using the profit evaluation function, the host computer receives data representing the quality of the fabric, the operating rate of the loom and power consumption from the loom. Then, the host computer calculates the profit evaluation value b on the basis of the input data by using the profit evaluation function properly weighting the factors of the profit evaluation function. Then, the calculated profit evaluation value b is compared with a reference profit evaluation value previously stored in the host computer. Then, control data is fed to the control unit of the loom to change only the operating speed n of the loom, only the pressure p of the picking fluid, or both the operating speed n and the pressure p in order to maximize the profit evaluation value b. Then, other controlled variables, such as picking fluid jetting timing and warp tension, are adjusted accordingly. Thereafter, the control unit controls the loom on the basis of the control data for optimum loom control.

Detailed Description Text - DETX (14): The control unit 1 of the loom comprises a CPU (central processing unit) 2, a RAM (random access memory) 3, a ROM (read-only memory) 4, a keyboard 5, an input port 6 and an output port 7, which are interconnected by a bus 8. The CPU 2 receives data representing the number P of effective picks, the unit power consumption W and the picking fluid consumption a through the input port 6 from a measuring unit 9 (FIGS. 4 and 5), and processes the data to obtain a profit evaluation value b. Then, the CPU 2 feeds control signals to an associated loom 13 according to the control procedure of FIG. 1 to set the loom 13 for an operating speed n and a pressure p for optimum control.

Detailed Description Text - DETX (17): The control unit 1 of the individual loom 13 comprises a control computer 20, a communication unit 21, a set point changing unit 22, an inverter 23 and an input unit 25. The control computer 20 receives data representing the operating speed n and the pressure p of the picking fluid through the communication unit 21, drives the set point changing unit 22 to adjust the operating conditions of the loom 13 including the pressure p of the picking fluid, changes the output frequency of the inverter 23 to change the operating speed n of the main motor 24 of the loom 13. While the loom 13 is in a weaving operation, the control computer 20 receives data representing the operating conditions of the loom 13 through the input unit 25, and sends the data through the communication unit 21 to the host computer 10. Then, the host computer 10 calculates a profit evaluation value b again, decides the course of optimum control, decides values of the operating speed n of the loom 13 and the pressure p of the picking fluid so that the profit evaluation value approaches an optimum value, and feeds control signals representing new set points of the operating speed n and the pressure p of the picking fluid to the control unit 1 of the loom 13. Thus, the host computer 10 calculates the profit evaluation value b several times and the control unit 1 of the loom 13 changes the set point of the operating speed n and the pressure p of the picking fluid according to control singals given thereto from the host computer 10 to decide final control conditions maximizing the profit evaluation value b.

Detailed Description Text - DETX (23): In step 9, the profit evaluation values b.sub.1 and b.sub.2 are compared, and then the control routine is branched in accordance with the result of the comparison. When the second profit evaluation value b.sub.2 is equal to or greater than the first profit evaluation value b.sub.1, namely, when the loom is controlled in a state as shown in FIG. 7(A), a new target operating speed n.sub.3 =N+2.DELTA.N is set, data representing the operating condition of the loom is collected, and then a third profit evaluation value b.sub.3 is calculated in steps 10 through 12. When the second profit evaluation value b.sub.2 is less than the first profit evaluation value b.sub.1, namely, when the loom is controlled in a state as shown in FIG. 7(B), b.sub.3 =b.sub.2, b.sub.2 =b.sub.1, n.sub.3 =n.sub.2 and n.sub.2 =n.sub.1 are set again, a target operating speed n.sub.1 =N-.DELTA.N is set, data representing the results of the control is collected, and then a third profit evaluation value b.sub.3 is calculated in steps 13 through 16.

Detailed Description Text - DETX (24): After thus calculating the profit evaluation values b.sub.1, b.sub.2 and b.sub.3 for the three target operating speeds n.sub.1, n.sub.2 and n.sub.3, a determination is made in step 17 as is whether or not the profit evaluation value varies along a monotonically increasing curve or a curve having a minimum. When the decision in step 17 is affirmative, b.sub.1 =b.sub.2, b.sub.2 =b.sub.3, n.sub.1 =n.sub.2, and n.sub.2 =n.sub.3 are set in step 18, and then a target operating speed n.sub.3 =n.sub.3 +.DELTA.N is set in step 19.

Detailed Description Text - DETX (25): When the decision in step 17 is negative, a determination is made in step 20 as to whether or not the profit evaluation value varies along a monotonically decreasing curve. When the decision in step 20 is affirmative, b.sub.3 =b.sub.2, b.sub.2 =b.sub.1 n.sub.3 =n.sub.2 and n.sub.2 =n.sub.1 are set, and then a target operating speed n.sub.1 =n.sub.1 -.DELTA.N is set.

Detailed Description Text - DETX (27): The host computer 10 or the control unit 1 repeats the foregoing control program to decide a target operating speed n for the individual loom 13 in accordance with the operating characteristics of the same loom 13, and controls the controllable variables to maximize the profit evaluation value so that an optimum operating condition of the loom 13 is established.

Detailed Description Text - DETX (36): The pressure p is controlled to further maximize the profit evaluation value b under an operating speed at which the profit evaluation value reached the maximum in step 1.

Detailed Description Text - DETX (51): The operating speed n.sub.2 is changed with reference to a curve on which the profit evaluation values b.sub.1, b.sub.2 and b.sub.3 are plotted so that the profit evaluation value is further increased. Subsequently, a control operation similar to that shown in FIG. 6 is executed to set the loom for an optimum operating condition.

US-PAT-NO: 6157916

DOCUMENT-IDENTIFIER: US 6157916 A

TITLE: Method and apparatus to control the operating speed of a papermaking facility

DATE-ISSUED: December 5, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hoffman; Roger Paul	Green Bay	WI	N/A	N/A

US-CL-CURRENT: 705/8, 702/182 , 702/188 , 705/1 , 705/11 , 705/7

ABSTRACT: A method and apparatus for controlling the operating speed of a papermaking facility is disclosed. It includes determining a desired operating speed that is dependent on at least one economic variable. The variables vary with the operating speed. Also, the operating speed is adjusted (if necessary) in response to the determination. Preferably the control is closed loop and includes determining a current operating speed and comparing the current operating speed to the desired operating speed. The operating speed is controlled in response to the comparison. The economic variable is preferably a cost of manufacturing, and/or manufacturing inflows, and/or manufacturing outflows. Also, a method and apparatus that determines the effect of one or more business transactions on the economic efficiency of the production of products in a paper manufacturing facility is disclosed. The economic efficiency is dependant on one or more economic variables that vary with operating speed. The current economic efficiency of the facility is obtained along with information on the business transactions that affects the economic variables. The economic efficiency of the facility with the proposed transaction, leaving the remaining variables constant is calculated. Then, the result is displayed to the end user.

39 Claims, 3 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 3

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Abstract Text - ABTX (1): A method and apparatus for controlling the operating speed of a papermaking facility is disclosed. It includes determining a desired operating speed that is dependent on at least one economic variable. The variables vary with the operating speed. Also, the operating speed is adjusted (if necessary) in response to the determination. Preferably the control is closed loop and includes determining a current operating speed and comparing the current operating speed to the desired operating speed. The operating speed is controlled in response to the comparison. The economic variable is preferably a cost of manufacturing, and/or manufacturing inflows, and/or manufacturing outflows. Also, a method and apparatus that determines the effect of one or more business transactions on the economic efficiency of the production of products in a paper manufacturing facility is disclosed. The economic efficiency is dependant on one or more economic variables that vary with operating speed. The current economic efficiency of the facility is obtained along with information on the business transactions that affects the economic variables. The economic efficiency of the facility with the proposed transaction, leaving the remaining variables constant is calculated. Then, the result is displayed to the end user.

Brief Summary Text - BSTX (11): For example, it may be determined that the average additional bleaching activity required to achieve a certain level of additional delignification will cost $20 per ton of pulp, based on an average cost of bleaching. A pulp mill operator may, therefore, allow the digester to operate at a level that exceeds its capacity because such operation is considered efficient if the additional bleaching costs are actually $20 per ton. When all variables are considered, however, it may be discovered that the additional bleaching action required on a certain level of marginal operating speed may be measured to actually reach $100 per ton due to the non-proportional demands for bleaching chemicals, energy, and effluent treatment. Current controls do not calculate from the necessary variables the total additional bleaching cost on the marginal operating speed, and subsequently limit digester operations to not incur the additional inefficient bleaching.

Brief Summary Text - BSTX (17): In making equipment operating speed decisions, the current control systems fails to account for the price component of the economic efficiency of a particular activity. While productive and qualitative measurements of equipment operations are essential to establishing an appropriate efficient operating speed, the individual price components of input materials, processing or manufacturing, and value of outputs should also be factored into calculating the efficient operating speed of equipment. For example, under the current control system, additional steam showers may be added to the papermarking process on a paper machine to increase the operating speed. Current controls systems would dictate operating at the increased rate, without factoring the incremental use of the additional steam.

Brief Summary Text - BSTX (20): According to a first aspect of the invention a method of controlling, and apparatus, which can include a computer program, that controls, the operating speed of a papermaking facility includes determining a desired operating speed. The desired operating speed is dependent on at least one economic variable that varies depending on the operating speed. Also, the operating speed is adjusted (if necessary) in response to the determination.

Brief Summary Text - BSTX (22): Another embodiment includes determining the desired speed where the economic variable is a cost of manufacturing, and/or manufacturing inflows, and/or manufacturing outflows.

Brief Summary Text - BSTX (23): The desired operating speed is determined by calculating the cost of manufacturing, the manufacturing inflow, and the manufacturing outflow at a plurality of potential operating speeds. Then the desired operating speed is selected from the potential operating speeds, in an alternative. The desired operating speed is determined by calculating a marginal cost of manufacturing, a marginal manufacturing inflow, and a marginal manufacturing outflow at a plurality of marginal potential operating speeds in another alternative. The desired operating speed is selected from the marginal potential operating speeds and a prior desired operating speed.

Brief Summary Text - BSTX (24): The economic variable is cost of manufacturing, and the cost of manufacturing includes ascertaining the correlation between operating speed and the cost of

manufacturing, in yet another embodiment. The cost of manufacturing may be determined by ascertaining a correlation between operating speed and the per-unit cost of manufacturing inflows and/or the usage of manufacturing inflows. Also, the correlation between manufacturing cost and operating speed may be ascertained by establishing the correlation between manufacturing costs and operating speed of specific equipment or process in a paper manufacturing facility. In another alternative the correlation between manufacturing cost and the operating speed of a paper machine includes the manufacturing inflows during sheet breaks and/or while the facility is producing finished product of unacceptable quality.

Brief Summary Text - BSTX (25): Another alternative provides that the correlation between manufacturing cost and operating speed is ascertained by establishing the correlation between manufacturing costs and the operating speed of groups of equipment or processes in a paper manufacturing facility. Also, the purchase price of manufacturing inflows may be assigned, from lowest to highest per-unit cost, to increasing levels of the paper manufacturing facility's production.

Brief Summary Text - BSTX (26): Yet another alternative provides that the manufacturing outflow is determined by ascertaining a correlation between operating speed and sales of at least one of finished products and byproducts. The correlation between the operating speed and sales may be ascertained by assigning a plurality of manufacturing outflows to at least one specific portion of the paper manufacturing facility's production. Alternatively, the correlation between operating speed and sales may include variations in product mix. The manufacturing outflow is determined, from highest to lowest per-unit economic value, for increasing levels of the paper manufacturing facility's production, in one embodiment.

Brief Summary Text - BSTX (27): A second aspect of the invention is a method and apparatus that determines the effect of one or more business transactions on the economic efficiency of the production of products in a paper manufacturing facility. The economic efficiency is dependent on one or more economic variables that vary with operating speed. It includes obtaining the current economic efficiency of the facility and inputting information on the business transactions that affects the economic variables. Also, the economic efficiency of the facility with the proposed transaction leaving the remaining variables constant is calculated. Then, the result is displayed to the end user.

Brief Summary Text - BSTX (28): In one embodiment the operating speed of the paper manufacturing facility is dependent on at least one economic variable that varies depending on the operating speed. In another embodiment, the transactions include one or more of purchase of inflows, sales of outflows, capital additions, capital subtractions, changes to equipment, change in product mix. In a third alternative the business transactions are proposed business transactions.

Detailed Description Text - DETX (6): The variables that are dependant on the operating speed can include: the variable usage of manufacturing inflows, the variable cost of manufacturing inflows and the variable economic value of manufacturing outflows.

Detailed Description Text - DETX (7): Manufacturing inflows include raw materials and/or other manufacturing supplies that are utilized in the manufacturing process that has either per-unit cost or usage that varies with operating speed. For a pulp and paper manufacturing facility, these may include, but are not limited to, pulpwood, wood chips, secondary or post-consumer recyclable fiber, purchased virgin pulp, purchased secondary or post consumer pulp, water, pulping chemicals, bleaching chemicals, paper additive chemicals, electricity, fossil fuels of any type, purchased steam, paper machine felts, paper machine wires, labor costs (to the extent that it varies with production speed), effluent treatment chemicals and paper finishing chemicals (such as coating and sizing ingredients). Costs for outside services that substitute for activities within the facility should also be included as manufacturing inflows if they vary with Operating Speed. For example, payments to municipalities to handle excess effluent treatment are in lieu of the chemical, energy and other supply purchases that are associated with in-facility effluent treatment, and therefore, should be considered as a manufacturing inflow.

Detailed Description Text - DETX (12): Finished goods and sellable byproducts, which are referred to as manufacturing outflows, can also have a value assigned to help establish the optimal operating speed of equipment based on economic efficiency. These values can vary based on the operating speed of the equipment. This is referred to as the variable economic value of manufacturing outflows. The value assigned could be the net sales price of finished goods. These prices could be input into the inventive control system manually or electronically through other information systems within the facility. They could also be input through physical observation or by feedback systems designed solely to work with this inventive control system.

Detailed Description Text - DETX (15): The optimal operating speed, in terms of economic efficiency, can be defined as the operating speed that provides the highest amount of positive difference between the facility value of manufacturing outflows and the cost of manufacturing.

Detailed Description Text - DETX (16): Manual or automatic adjustments of the operating speed of a particular piece of equipment or process is made after the inventive control system computes the optimal operating speed. The inventive control system computes a revised optimal operating speed as variables in the process change, such as changes in variable usage or costs of manufacturing inflows, either instantaneously or at a later time. The inventive control system will then be used to either initiate manual or automatic adjustments to the operating speed of the equipment to achieve the new optimal operating speed.

Detailed Description Text - DETX (29): FIG. 2 represents the sub-activity of determining the optimal operating speed of the paper machine (block 103 of FIG. 1). Block 200 represents the activity of inputting all the variable cost of manufacturing inflows. This may be done manually or electronically at the occurrence of the actual purchases. For example, when a purchase of wood is made by the purchasing department of a papermaking facility, either manual data on cost and quantity are entered or such data is automatically transferred from the computer system handling the purchase information.

Detailed Description Text - DETX (31): One purpose of inputting the quantity of each variable

manufacturing inflow purchase is to establish the quantities of available resources. This will help determine the optimal operating speed based on the available resources. Further, information on quantity of purchases will aid in determining the variable usage of manufacturing inflow alternatives. For example, the inflow data may establish that pulp wood purchases can only be made to fulfill 75 % of the facility's potential operating speed. Additional operating speed will, therefore, have to be met through an alternative variable manufacturing inflow, such as purchased wood chips or market pulp. This may lead to less economic efficiency at higher operating speeds, which results in a lower optimal operating speed compared to a facility that can fulfill its pulp requirements internally.

Detailed Description Text - DETX (35): A paper manufacturing facility, ideally, purchases its manufacturing inflow items in an increasing per-unit cost fashion based on operating speed. This means that the purchasing departments are securing manufacturing inflows with the lowest per-unit cost before investigating purchases of greater cost. Consequently, if the operations were curtailed, the highest per-unit cost raw materials would not be purchased. Under this arrangement, per-unit cost of inflows is directly correlated to increasing operating speed. More particularly, this would result in the use of a particular item of inflow with the highest per-unit cost to fulfill the last quantity needed by the facility to operate at full speed. Conversely, as speed decreases, less expensive per-unit inflows would be utilized. If this behavior exists or is desired, the purchase grid from the input data in activity block 200 would be layered in the block 210 activity in a fashion of increasing per-unit costs so that inflows are retrieved in a least-expensive-out-first fashion.

Detailed Description Text - DETX (39): Since the optimal operating speed is determined by marginal transactions, the operator may chose only to include those purchases above a certain operating speed. For example, an operator may not want to include low cost wood purchases that represent the first 50 % of operating speed because the operator knows that the facility could never be efficient below this speed.

Detailed Description Text - DETX (44): Usage of different types of manufacturing inflows will occur at different speeds of equipment. For example, a paper machine speed increase will likely result in an increase in pulp usage. If the pulp operation of the facility is limited to only supplying 80 percent of the fiber requirements of the paper machine running at full speed, the manufacturing inflow usage of purchased market pulp will be required, whereas operations below 80 % may not dictate such usage. Purchased pulp would become a necessary inflow usage at levels above 80 %. Alternatively, purchased pulp could be assigned a cost of zero below 80 %. The optimal facility efficiency will dictate whether purchased pulp will become part of the manufacturing inflows for speeds below 80 %.

Detailed Description Text - DETX (45): Block 212 represents the activity of establishing the variable manufacturing cost for individual equipment or process. This activity involves applying the manufacturing inflow cost from the purchase grid developed in the activity at block 210 to each piece of equipment's variable usage of manufacturing inflows established in block 202. As discussed above, items retrieved from the purchase grid will be done so in a specific order as established by the user of the inventive control system. One possibility, as discussed above, would

be based on a lowest-cost-first priority. The results of the activity in block 212 will be to establish a correlation between potential equipment or process operating speeds and the cost of manufacturing.

Detailed Description Text - DETX (47): Activity block 220 involves the process of solving for the optimal operating speed of individual equipment or process when joined with other equipment or processes to form larger processes or groups of equipment that can have their own measurable operating speeds. The activity in block 220 also involves computes the variable cost of manufacturing of the larger processes or groups of equipment.

Detailed Description Text - DETX (48): For example, pulp digesters and bleaching equipment are separate pieces of equipment that can be analyzed in the activity at block 212. This equipment can, however, be grouped into larger categories of production or processes. For example, each separate piece of bleaching equipment can then be grouped together to be analyzed for various operating speeds of the entire bleaching process. Further, since part of the bleaching process involves delignification, it can be grouped with other equipment (such as the digesters) to establish the variable cost of manufacturing in the delignification process. This also shows that equipment can become part of more than one grouping (i.e. bleaching and delignification).

Detailed Description Text - DETX (51): Block 224 represents a data arrangement activity for manufacturing outflows that is similar to the activity occurring in block 210 for manufacturing inflows. Block 224 arranges the variable economic value of manufacturing outflow data inputs of block 222 in a layered fashion based on per-unit price of sales, which is referred to as the outflow grid. In the ideal environment, a paper manufacturing facility would be able to show a direct inverse correlation between net per-unit sales price of outflows and operating speed. If this occurs, the operator would establish a system in activity block 224 to arrange the data from block 222 in layers of decreasing per-unit price. These layers could be utilized by later steps of the inventive control system (described below) in a fashion of the highest per-unit value down to the lowest per-value unit based on operating speed.

Detailed Description Text - DETX (52): A simple example of the activity in block 224 would be for a facility that only has two sales: one sale that covers 75 percent of the potential operating speed of the paper machine is at a net per-unit sale of $500. The other sale that covers 25 percent of the potential operating speed of the machine has a $400 net per-unit sale price. In establishing the optimal speed, the inventive control system could assume that the $500 per-unit sales for operations would be made before the $400 per-unit sales (other assumptions could be made).

Detailed Description Text - DETX (55): Block 230 represents the activity of evaluating the efficiency of the facility at different possible paper machine operating speeds. To accomplish this task, the activity in block 230 represents the comparison of the variable cost of manufacturing (established in block 220) to the variable economic value of manufacturing outflows (block 224) at different paper machine operating speeds. As discussed above, block 224 provides the per-unit price layers of economic value of manufacturing outflows. As also discussed above, these layers could be arranged by decreasing prices, so that the highest marginal operating speed results in the

lowest marginal per-unit sale.

Detailed Description Text - DETX (58): The desired optimal operating speed may be defined as the operating speed that produces products and byproducts with the greatest excess of variable manufacturing cost over the economic value of manufacturing outflows. This speed also represents the speed at which the largest positive numerical sum can be obtained from the product of subtracting the variable manufacturing cost from the economic value of manufacturing outflows. This numerical sum is referred to as the greatest economic efficiency. If this is the selected definition, then one possibility for the methodology of carrying out the activity of block 240 would be to select from the resulting potential operating speeds in block 230 the operating speed that has a facility performance that achieves the greatest economic efficiency.

Detailed Description Text - DETX (59): As data changes, the inventive control system will establish new optimal operating speeds in the manner described in FIG. 2 and adjust the equipment speed to achieve the new optimal operating speed as described in FIG. 1. For example, if a new high per-unit cost wood purchase is input in activity 200, it may ultimately result in a paper machine operating speed of 3,000 feet per minute for a single machine facility. The activity in Block 101(using a closed-loop control system) may measure that the current machine operating speed is 3,100 feet per minute (based on a prior set optimal operating speed before the expensive wood purchase). The activity represented in block 107 would compare the operating speed determined in block 101 with the determined revised optimal operating speed result from the activity represented in block 105 (which for the paper machine, was already computed from activity 103). The activity represented in block 109 would be a 100-foot per minute downward adjustment of paper machine speed from 3,100 feet per minute to 3,000 feet per minute.

Detailed Description Text - DETX (62): Block 302 represents the activity of retrieving information from the activity in FIG. 2 relating to the current paper machine optimal operating speed calculations. Some examples of this information are: the current optimal speed, the current facility optimal economic efficiency, the current cost structure of the wood inventory (from its purchase grid), and the current selection of the highest wood cost being utilized from the wood purchase grid at the optimal paper machine operating speed.

Detailed Description Text - DETX (65): Block 308 represents the activity of displaying the information obtained from blocks 302, 304 and 306 for the purpose of providing useful information to aid in making the purchase decision. Examples of this information includes comparisons of current operations to "what if" scenarios for the purpose of showing the effect that the purchase has on optimal operating speed and efficiency, the effect that the purchase has on the average cost of wood utilized at the current optimal operating speed, information on the effect of the purchase on operating speed and economic efficiency based on different hypothetical wood purchase quantities at the proposed price. Other embodiments include using lookup tables, or solving equations based on marginal changes in one or more variables.

Detailed Description Text - DETX (66): As mentioned above, a similar methodology could be followed for sales decisions. Further, similar methodology could also be employed to determine

the effect on economic efficiency and operating speed for other decisions. These could include decisions on capital equipment additions, capital equipment deletions, proposed changes in the processes, or changes to other operating variables.

Detailed Description Text - DETX (70): To establish the electronic connection to the equipment, inputs and outputs from the inventive control system could be integrated with other existing control or information systems in the facility. For example, existing controls of equipment could provide input on the variable usage of manufacturing inflows and also could implement the computed optimal operating speed established by the inventive control system. Similarly, accounting and other information systems could also provide cost information for the manufacturing inflows, the manufacturing inflow usage, and the economic value of manufacturing outflow information. Ancillary data computed by the inventive control system (discussed above) could also be integrated with the other systems to provide information to the operators and other departments in the facility.

Claims Text - CLTX (2): Determining a desired operating speed, the desired operating speed dependent on at least one economic variable that varies depending on the operating speed; and

Claims Text - CLTX (9): 4. The method of claim 3, wherein the desired operating speed is determined by calculating the cost of manufacturing, the manufacturing inflow, and the manufacturing outflow at a plurality of potential operating speeds, and selecting the desired operating speed from the potential operating speeds.

Claims Text - CLTX (10): 5. The method of claim 3, wherein the desired operating speed is determined by calculating a marginal cost of manufacturing, a marginal manufacturing inflow, and a marginal manufacturing outflow at a plurality of marginal potential operating speeds and selecting the desired operating speed from the marginal potential operating speeds and a prior desired operating speed.

Claims Text - CLTX (14): 9. The method of claim 1, wherein the economic variable is cost of manufacturing, and the cost of manufacturing includes ascertaining the correlation between operating speed and the cost of manufacturing.

Claims Text - CLTX (15): 10. The method of claim 9, wherein the cost of manufacturing is determined by ascertaining a correlation between operating speed and at least one of the following: the per-unit cost of manufacturing inflows and the usage of manufacturing inflows.

Claims Text - CLTX (16): 11. The method of claim 10, wherein the correlation between manufacturing cost and operating speed is ascertained by establishing the correlation between manufacturing costs and operating speed of specific equipment or process in a paper manufacturing facility.

Claims Text - CLTX (17): 12. The method of claim 10, wherein the correlation between manufacturing cost and the operating speed of a paper machine includes the manufacturing inflows

during one or more of sheet breaks and production that produces finished product of unacceptable quality.

Claims Text - CLTX (18): 13. The method of claim 10, wherein the correlation between manufacturing cost and operating speed for a paper machine is determined by including usage of manufacturing inflows associated with paper breaks.

Claims Text - CLTX (19): 14. The method of claim 10, wherein the correlation between manufacturing cost and operating speed is ascertained by establishing the correlation between manufacturing costs and operating speed of groups of at least one of equipment and processes in a paper manufacturing facility.

Claims Text - CLTX (23): means for determining a desired operating speed, the desired operating speed dependent on at least one economic variable that varies depending on the operating speed;

Claims Text - CLTX (25): 17. The apparatus of claim 16, wherein the means for determining includes means for determining a desired operating speed to achieve an optimal operating speed from at least one of: a cost of manufacturing, at least one manufacturing inflow, and at least one manufacturing outflow.

Claims Text - CLTX (26): 18. The apparatus of claim 17, wherein the means for determining includes means for determining a desired operating speed by calculating the cost of manufacturing, the manufacturing inflow, and the manufacturing outflow at a plurality of potential operating speeds and selecting the desired operating speed from the potential operating speeds.

Claims Text - CLTX (27): 19. The apparatus of claim 17, wherein the means for determining include means for determining a desired operating speed by calculating a marginal cost of manufacturing, a marginal manufacturing inflow, and a marginal manufacturing outflow at a plurality of marginal potential operating speeds and selecting the desired operating speed from the marginal potential operating speeds.

Claims Text - CLTX (28): 20. The apparatus of claim 18, wherein the means for determining include means for determining a desired operating speed by ascertaining the correlation between operating speed and the cost of manufacturing.

Claims Text - CLTX (29): 21. The apparatus of claim 20, including means for determining the variable cost of manufacturing by ascertaining a correlation between operating speed and at least one of the following: the per-unit cost of manufacturing inflows and the usage of manufacturing inflows.

Claims Text - CLTX (35): computer readable program code means for receiving as an economic input at least one economic variable that varies depending on the operating speed;

Claims Text - CLTX (43): 27. The article of claim 25, wherein the means for determining includes

computer readable program code means for determining a desired operating speed from at least one of: cost of manufacturing, manufacturing inflows, and manufacturing outflows.

Claims Text - CLTX (44): 28. The article of claim 27, wherein the means for determining includes computer readable program code means for determining a desired operating speed by calculating the cost of manufacturing, the manufacturing inflow, and the manufacturing outflow at a plurality of potential operating speeds and selecting the desired operating speed from the potential operating speeds.

Claims Text - CLTX (45): 29. The article of claim 27, wherein the means for determining includes computer readable program code means for determining a desired operating speed by calculating a marginal cost of manufacturing, a marginal manufacturing inflow, and a marginal manufacturing outflow at a plurality of marginal potential operating speeds and selecting the desired operating speed from the marginal potential operating speeds that contribute to achieving an optimal operating speeds.

Claims Text - CLTX (47): 31. The article of claim 29, wherein the economic variable is cost of manufacturing, and further including computer readable program code means for ascertaining the correlation between operating speed and the cost of manufacturing.

Claims Text - CLTX (48): 32. The article of claim 31, further including computer readable program code means for ascertaining a correlation between operating speed and at least one of the following: the per-unit cost of manufacturing inflows and the usage of manufacturing inflows.

Claims Text - CLTX (49): 33. The article of claim 31, further including computer readable program code means for establishing the correlation between manufacturing costs and operating speed of specific equipment or process in a paper manufacturing facility.

Claims Text - CLTX (50): 34. The article of claim 31, further including computer readable program code means for correlating the manufacturing cost and the operating speed of a paper machine including the manufacturing inflows utilized during one or more of sheet breaks and to periods in which finished product of unacceptable quality is produced, measured by including such manufacturing inflows utilized with other manufacturing inflows utilized in the paper machine operation.

Claims Text - CLTX (52): 36. The article of claim 31, further including computer readable program code means for correlating the manufacturing cost and operating speed for a paper machine by including usage of manufacturing inflows associated with paper breaks and finished goods of unacceptable quality.

Claims Text - CLTX (54): 38. The article of claim 31, further including computer readable program code means for correlating the manufacturing cost and operating speed by establishing the correlation between manufacturing costs and operating speed of groups of equipment or processes in a paper manufacturing facility.

US-PAT-NO: 6378408
DOCUMENT-IDENTIFIER: US 6378408 B2
TITLE: Apparatus for variably controlling work feed rate for cutting wood, metal and other materials
DATE-ISSUED: April 30, 2002
INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Smith; H. Reid	Kooskia	ID	N/A	N/A

US-CL-CURRENT: 83/75, 700/193 , 83/74 , 83/76

ABSTRACT: A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.
1 Claims, 10 Drawing figures
Exemplary Claim Number: 1
Number of Drawing Sheets: 7

---------- KWIC ---------

Abstract Text - ABTX (1): A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.

Brief Summary Text - BSTX (6): Circular saw and bandsaw machines have long been used as economical means for cutting wood, metal and other materials. In recognition of the high costs for raw material and labor, automatic/computer control of work feed rates and sawing accuracy becomes of paramount importance. Optimized automatic control of work feed rates and saw blade stability keeps material and production costs down. The use of thinner saw blades and smaller rough sawn dimension sizes can conserve natural resources in the wood products industry, and reduce material waste in all industries which use circular saw and bandsaw machines in the manufacturing process. In the lumber industry, current production methods result in a larger than necessary amount of waste in order to manufacture finished dimension lumber. Reduction of this waste requires the solution of several technical problems.

Detailed Description Text - DETX (28): The work, which as previously stated in this description of the Best Mode is a log or cant 28, passes through a depth of cut thickness measurement means 70 prior to feed entry into the saw blade so that its thickness is measured and compared to a predetermined entry feed rate table and the appropriate output value is sent to the work feed motor 24 to move the log or cant into the saw blade at the appropriate predetermined speed. The depth of cut or thickness measurement means 70 is typically a set of optical sensors, or other devices, all of which are well known in the art.

US-PAT-NO: 6382062

DOCUMENT-IDENTIFIER: US 6382062 B1

TITLE: Apparatus for controlling work feed rate for cutting wood, metal and other materials

DATE-ISSUED: May 7, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Smith; H. Reid	Kooskia	ID	N/A	N/A

US-CL-CURRENT: 83/74, 700/193 , 83/76 , 83/789 , 83/801

ABSTRACT: A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.

1 Claims, 8 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 5

---------- KWIC ---------

Abstract Text - ABTX (1): A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.

Brief Summary Text - BSTX (6): Circular saw and bandsaw machines have long been used as economical means for cutting wood, metal and other materials. In recognition of the high costs for raw material and labor, automatic/computer control of work feed rates and sawing accuracy becomes of paramount importance. Optimized automatic control of work feed rates and saw blade stability keeps material and production costs down. The use of thinner saw blades and smaller rough sawn dimension sizes can conserve natural resources in the wood products industry, and reduce material waste in all industries which use circular saw and bandsaw machines in the manufacturing process. In the lumber industry, current production methods result in a larger than necessary amount of waste in order to manufacture finished dimension lumber. Reduction of this waste requires the solution of several technical problems.

Detailed Description Text - DETX (18): The work, which in this description of the Best Mode is a log 28, passes through a depth of cut thickness measurement means 70 prior to feed entry into the saw blade so that its thickness is measured and compared to a predetermined entry feed rate table and the appropriate output value is sent to the work feed motor 20 to move the log or into the saw blade at the appropriate predetermined speed. The depth of cut or thickness measurement means 70 is typically a set of optical sensors, or other devices, all of which are well known in the art.

US-PAT-NO: 6640152
DOCUMENT-IDENTIFIER: US 6640152 B1
TITLE: Modeling and control of sheet weight and moisture for paper machine transition
DATE-ISSUED: October 28, 2003
INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chen; Shih-Chin	Dublin	OH	N/A	N/A
Murphy; Timothy F.	Columbus	OH	N/A	N/A

US-CL-CURRENT: 700/128, 162/198 , 162/253 , 162/254 , 162/259 , 162/262 , 700/122 , 700/127 , 700/129 , 700/305 , 700/52

ABSTRACT: Headbox transient responses for sheet weight and moisture are modeled as a combination of two sets of time constants and dead time delays. One set represents a shorter delay with faster response dynamics, the fast mode weight and moisture responses, and the other models the longer delay with slower dynamics, the slow mode weight and moisture responses. A weight and/or moisture transient model is then formed for headbox changes by combining the fast mode weight and moisture responses and the slow mode weight and moisture responses. Stock weight and moisture dynamic and delay time models are determined for operation of stock flow of the paper making machine and the stock flow is controlled in accordance with the stock weight and/or moisture models and the headbox weight transient and/or moisture transient model to compensate for weight and moisture changes in a web of paper being manufacture which weight and moisture changes result from headbox changes.
5 Claims, 32 Drawing figures
Exemplary Claim Number: 1
Number of Drawing Sheets: 8

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Detailed Description Text - DETX (5): One of the most common phenomena during a grade change transition is an irregular weight and moisture change. Typically, the weight and moisture sharply change shortly after the grade change starts and slowly approach their new steady-state levels if the feedback control loops are not enabled to chase after the transient deviations. If the feedback control loops are enabled during the grade change, the feedback controls can be misguided and induce further unwanted process deviations. Such irregular process change was thought to be associated with the transport phenomena that occurred in the dryer section. It was generally believed that the uneven drying, as the result of machine speed change, caused the moisture disturbance during the transition. However, based on experimental tests applicants have performed on paper making machines, the dynamics of headbox total head pressure has been identified as the main source of this type of process disturbance.

Detailed Description Text - DETX (6): A new strategy to reduce these process disturbances relies on changing the stock flow to compensate for the effects of the total head and machine speed changes. This specific approach results in major improvements

in stabilizing grade changes in paper making machines. Thus, the present application specifically focuses on modeling and control of transient weight and moisture deviations which occur in the wet-end of a paper machine.

Detailed Description Text - DETX (7): Modeling and control of wet-end weight and moisture transient deviations which result from total head changes are key components of the present invention. Headbox control typically consists of total head, level, and dryline controls (of course there is no level control for a hydraulic headbox). Total head control is mostly driven by paper machine speed in order to maintain a specific jet-to-wire speed ratio (or rush-drag speed difference) target which is crucial to achieve desired paper properties such as formation and fiber orientation. Level control maintains a desirable liquid level in the headbox for sufficient mixing and provides required headbox pressure. Dryline control keeps pulp slurry on the wire for a proper distance to drain. During the steady-state operation when these control loops are maintained at specific settings, there is little indication of the impact of their dynamic operation. However, during a grade change transition, particularly changing the machine speed, the transient responses of these control loops can cause major transient deviations to grade change or speed change transitions.

Detailed Description Text - DETX (11): where g.sub.h.sup.w and g.sub.h.sup.m are weight (w) and moisture (m) gains with regard to total head change (h), respectively. Notation throughout the present application will show controlled variables subscripted and response variables superscripted which is consistent with the gains g.sub.h.sup.w and g.sub.h.sup.m just defined. T.sub.hd is the speed-dependent transport delay (d) with regard to total head change (h). T.sub.h1 and .tau..sub.h1 are pure delay and time constant of the faster response mode. T.sub.h2 and .tau..sub.h2 are pure delay and time constant of the slower response mode. All these parameters need to be identified from total head bump-tests. It is noted for the bump-test of a headbox total head that weight, moisture, machine speed, rush/drag, and slice (if there is any) feedback control loops have to be put in manual control mode while the bump-test is performed on the total head pressure.

Detailed Description Text - DETX (36): The main goal of speed change coordination is to maintain undisturbed sheet properties such as weight and moisture while the machine speed is increased or decreased for purposes such as the adjustment of the production throughput. When a machine speed change occurs, the total head pressure in the headbox has to change accordingly in order to maintain a desired jet-to-wire target. The indirect impact of speed on sheet weight and moisture through total head was frequently viewed as a speed change symptom in the past. In the present invention, such variations are treated as a side effect of changes to total head pressure and the aforementioned total head compensation control is applied to eliminate the transient deviations.

Detailed Description Text - DETX (37): As described above for total head compensation control, any request for a total head change has to be delayed by a T.sub.u -T.sub.h1 time interval in order to let stock compensation first take place. As a

result of total head coordination, for any speed change request the actual change to the machine speed also has to be delayed by a T.sub.u -T.sub.h1 time interval.

Detailed Description Text - DETX (53): where v'(s)=v(s)e.sup.T.sup..sub.v .sup.s or v(s)=v'(s)e.sup.-T.sup..sub.v .sup.s and T.sub.v is a delay time to make [G.sub.1.sup.-1 (s)G.sub.2 (s)e.sup.-T.sup..sub.v .sup.s] feasible. v'(s) is the change that activates the coordinated changes applied to stock flow, steam pressure, total-head, and machine speed controllers. Among stock flow, steam pressure, and total-head controllers, one of them immediately receives the change v'(s). The other controllers receive the changes v'(s) following the relative delays. The actual machine change v(s) applied to the speed controller is delayed by T.sub.v duration from v'(s).

Detailed Description Text - DETX (56): The ultimate goal of grade change is to achieve a smooth transition while a paper machine is changing from one set of operating conditions to a new set of operating conditions in order to produce a new grade of paper. The coordination among all process variables is more complex than what is needed for speed change coordination. Speed change can be considered a special case of generalized grade change where both weight and moisture targets are unchanged. For a given grade change, the coordination of machine speed with total head, stock flow, and steam pressure is basically the same as the coordination of speed change to total head; however, the weight and/or moisture target changes need additional stock and/or steam adjustments. These additional adjustments are superimposed on top of the machine speed coordination. Presume that r(s) is a master ramp needed for a grade change and all other ramping changes are associated with r(s) as:

Detailed Description Text - DETX (62): where r'(s)=r(s)e.sup.T.sup..sub.r .sup.s or r(s)=r'(s)e.sup.-T.sup..sub.r .sup.s and a delay time T.sub.r is added to make [G.sub.1.sup.-1 (s)G.sub.2 (s)e.sup.-T.sup..sub.r .sup.s] feasible. The starting ramp r'(s) is the common starting ramp that will activate the required changes to stock flow, steam pressure, total-head, and machine speed controllers. The starting ramp r(s) is the expected ramp of weight, moisture, jet-to-wire ratio, and machine speed.

US-PAT-NO: 6701816

DOCUMENT-IDENTIFIER: US 6701816 B2

TITLE: Apparatus for variably controlling work feed rate for cutting wood, metal and other materials

DATE-ISSUED: March 9, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Smith; H. Reid	Kooskia	ID	N/A	N/A

US-CL-CURRENT: 83/74, 83/789

ABSTRACT: A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.

2 Claims, 10 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 7

---------- KWIC ---------

Abstract Text - ABTX (1): A positioned sensing device measures and/or calculates the lateral position and movement of a saw blade. These measured and calculated values are used to automatically alter the work-feed rate and/or saw blade rim speed either up or down as sawing conditions change within the work piece or between different work pieces.

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Detailed Description Text - DETX (33): The work, which as previously stated in this description of the Best Mode is a log or cant 28, passes through a depth of cut thickness measurement means 70 prior to feed entry into the saw blade so that its thickness is measured and compared to a predetermined entry feed rate table and the appropriate output value is sent to the work feed motor 24 to move the log or cant into the saw blade at the appropriate predetermined speed. The depth of cut or thickness measurement means 70 is typically a set of optical sensors, or other devices, all of which are well known in the art.

18/9/4 (Item 4 from file: 2)
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Title: Optimum supervisory control of paper basis weight and machine speed by statistical methods
Author(s): Keyes, M.A.; Frerichs, D.K.; Kaya, A.
Author Affiliation: Bailey Controls Co., Wickliffe, OH, USA
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Abstract: A method for the control of basis weight by supervisory optimization is worked out. The objective is to determine the **optimum** supervisory **machine speed** and basis weight set-point adjustments to maximize the profitability of paper production subject to the constraints of plant **operation**. The **cost** function consists of **production cost** and the loss due to rejects. The **machine speed** versus profit relations are developed to arrive at a supervisory **machine speed** which provides the globally minimized **cost** (maximized profit). The sampled measurements are processed to determine the variance and expected **values** of **process** variables. The expected **values** are used by the optimization system to determine the set-point adjustments (corrections) by using the **production** and reject **cost** data. The supervisory **machine speed** is determined based on the **optimum cost values** of **operation** at various speeds in **order** to reach a globally minimum **cost** value. The implementation by distributed control systems and the benefits of the system are described. (14 Refs)

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